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Chicago Meeting of the American Electrochemical Society.

The program of the Chicago meeting of the American Electrochemical Society, printed elsewhere in this issue, is so attractive in all its features that a great many members from the East may be expected to attend it. The variety of excursions is certainly alluring. And it is a pleasure to note the many contributions from Western members, especially from Chicago and the University of Wisconsin, to the program of papers. We are sure that the meeting will be not only highly enjoyable, but that this first excursion to the West will have a far-reaching effect on the further development of the society.

Fixation of Atmospheric Nitrogen in the United States.

It is only during the last few years that the fascinating problem of combining by electrical means the nitrogen and oxygen in atmospheric air for the production of nitrates and nitric acid has been sufficiently worked out in detail to pass out of the hands of the research chemist into those of the works manager. This development in all its technical phases has been recorded in great detail in former issues and volumes of this journal. We shall say here only a few words on the geographical aspect of the commercial problem. The first commercial plants were erected in Norway for the reason that exceedingly cheap electric power (costing something like $4 or $5 per electric hp-year) is available there right on the coast, from where transportation on ocean steamers is also cheap. Then followed a commercial plant in Tyrol and some other plants, perhaps still more or less experimental, in France. Cheap electric power was the keynote of all these undertakings. Just for the same reason nothing has been done in the past in this country, where the cheapest electric power is sold at three times the cost quoted above for Norway. The fact that a 4000-hp experimental plant is now about to be erected in South Carolina is, therefore, of considerable interest and importance. Both the Guye process and the Pauling process shall be tried. Again the availability of large quantities of power is a decisive element, the undertaking being affiliated with the large water-power developments of the Southern Power Company. Of equal importance is the market which exists in the South for fertilizers. The outcome of this work will be watched with much interest. The technical problem appears to be solved, and it was all important not to make a commercial mistake now. It would seem that if the fixation of atmospheric nitrogen shall succeed in this country, the logical place has been chosen for the first trial.

Two Appointments

The appointment of Dr. Joseph A. Holmes to the directorship of the Bureau of Mines meets with the unanimous ap-

proval of the interests most concerned with the work of the new bureau. The appointment is gratifying for two reasons: first, it is but the just recognition of the qualifications and past work of the recipient, and, second, it augurs well for the success of the new bureau, for Dr. Holmes has shown his ability as an organizer and his knowledge of the needs of the industries which the bureau is to aid. Another appointment of interest to the metallurgical profession, and one which has called forth approval from many sources, is that of Mr. George E. Roberts to the directorship of the Mint. Mr. Roberts returns to the position formerly held by him after two years service as president of a large national bank.

The Chemistry of Slime.

Improvements in the handling of slime in the cyanide process have been almost entirely mechanical, and chemical considerations have been neglected, although the latter may materially affect the former. Recent investigations in the laboratory of the Clay Products Section of the Technologic Branch of the United States Geological Survey indicate that the principles of colloid chemistry may be applied to advantage in the treatment of slime, since some metallurgical slimes are true clays and the colloidal matter from certain crushed rocks is identical with portions of colloidal matter found in clays. A slime which is largely colloidal in nature is difficult to settle or filter, but it can be improved by coagulation. Experiments by Mr. H. E. Ashley, of the laboratory mentioned, although undertaken for the clay industry, may be of importance in metallurgy. The success of all sliming methods in cyaniding is dependent on the suppression of colloidal slime; the more completely it is suppressed the more rapid and successful the filtration. It is suggested that the formation of colloidal matter can be suppressed greatly by grinding the ore in coagulating solutions, such as lime, and sulphates and chlorides of calcium and magnesium.

The Destruction of Cyanide.

The practice of filling worked-out areas of metal mines with the tailing from milling operations is not new, although practiced only in those districts where mining has been conducted for long periods of time, or where the magnitude of operations makes it necessary to provide cheap and efficient means of filling to prevent subsidences of ground and to protect the lives of the miners. When tailing from cyanide works is to be used for this purpose, it is necessary to render it innocuous as a possible source of poison after it is placed underground. To do this effectively and economically constitutes an interesting chemical problem on account of the complex reactions which may occur. The complete destruction of cyanide would involve the dissociation of the cyanogen radical, and some of the methods proposed look toward this end; but probably the formation of non-poisonous salts of cyanide would serve the purpose, provided assurance could be given that subsequent reactions occurring after underground filling would not again release poisonous gases. The chemists of South Africa are at present engaged on this problem, and some most interesting experimental work has resulted.

In investigating the possibility of utilizing the reaction between cyanide and ferrous salts Dr. Moir, president of the South African Society of Chemists and Metallurgists, found that his experiments contradicted practically all of the textbook information on the ferrocyanide reaction. This is rather startling, but indicates that in attacking any problem it is not sufficient to apply stated principles relating to the subject, but that independent research may be necessary to determine the applicability of the principles. The results of his work may be summed up thus: In the reaction between cyanide and ferrous salts, if excess of alkali is used, less ferrocyanide is formed than when smaller quantities of alkali are present; a rise of temperature above 20° C. is harmful to the reaction; the results are almost independent of dilution, and the reaction is as complete in 5 to 10 seconds as after long standing; alkalinity must be carefully adjusted to the amount of iron used, otherwise an excess of ferrous solution gives no better results than that theoretically indicated in the reaction. The method is applicable, however, as the reaction can be made sufficiently complete for industrial purposes, the cyanide having been reduced to three or four parts per million.

The more complete destruction of cyanide is proposed by other investigators, by the use of alkaline permanganates, aldehydes or alkaline picrates. The first-mentioned substance oxidizes the cyanide to cyanate, but the latter two give organic products with potassium cyanide, although they have no effect on sulphocyanides or ferrocyanides. With formaldehyde the reaction is almost instantaneous in the cold, but the other reactions require from two to four hours. For practical trials of the cyanicides it is recommended that the chemicals be used in the following proportions: For every 100 tons of sand, 20 tons of solution of 0.045 per cent $KMnO_4$, or 0.027 per cent formalin (at 32 per cent formaldehyde), or 0.019 per cent picric acid as alkaline picrate. The direct expense for the chemicals would be probably from 1.2 cents to 2.6 cents per ton of sand treated.

Railroad Consumption of Steel.

A time has been reached when it is necessary to make a clear distinction between utilization, deterioration and destruction of steel. The broad term "consumption" has been used loosely and should be replaced, where possible, by more precise terms. It has been customary, for instance, to speak of the "consumption" of steel by the railroads. Few applications of steel involve less destruction or dissipation of material, as railroad scrap yards bear eloquent testimony. A rail unfit for further service weighs within a few per cent as much as it did when new. Car wheels lose between 5 and 10 per cent and brake shoes somewhat more. Locomotives, car parts, bridges and viaducts lose scarcely any material.

There was a time when the railroads absorbed more than one-half the total iron and steel production of the country. That was when the railroads were being built. They were destroying, or reducing to scrap, very little material. The tonnage of material dissipated or reduced to a condition requiring reworking by the entire railroad system of the country is chiefly a function of the total amount of work done, and as passenger service is light relative to freight service and has increased more or less uniformly with freight movement, a concise presentation of railroad activity is furnished by freight ton-mileage statistics. The ton-mileage of the steam

roads of the country, net tons moved one mile, has been as follows, according to Poor's statistics:

1885	49,151,894,469
1890	79,192,985,125
1895	82,219,900,498
1900	141,162,109,413
1905	187,375,621,537
1906	216,653,795,696
1907	233,137,507,807
1908	215,698,911,350
1909	227,198,932,735

It is instructive to recall that in 1887 rail production amounted to 2,139,640 tons and that as large an annual total was not reached again until 1899, when production amounted to 2,272,700 tons. This long hiatus, during which freight ton-mileage increased from 61,561,069,996 in 1887 to 126,991,703,110 in 1899 illustrates the fact that in those days rails were not required principally because other rails had worn out. The railroads are now doing almost four times as much work as in 1887, but are not calling for four times as large a tonnage of rails. Indeed, it is evident from the ton-mileage table just given that it is only in recent years that rails are being worn out rapidly. From such statistics as are available an effort has been made to determine a factor of ton-mileage per ton of rails worn out. The statistics are too meager to promise an accurate result, but it is probable that the factor, subject to correction for local conditions, probably does not lie outside the limits of 250,000 and 300,000 ton-miles per ton of rails.

When the rail is made unfit for further service it comes into the steel industry for treatment. A limited tonnage unfit merely because of deformation of the head is "renewed," another tonnage is rerolled into lighter sections, another tonnage is rolled into concrete reinforcing bars, bedstead angles and the like and the remainder, the largest tonnage of all, is remelted in the open-hearth steel furnace. For the future there is promised a large flow of steel through railroad use, larger in proportion to the absorption than has obtained in the past. The flow of steel through the period of utilization is more distinct in the case of rails than in the case of any other large channel.

New Markets for Cobalt.

For a great many years the complex arsenides of silver cobalt, nickel, and iron have been a steady source of supply to the small metallurgical works of Saxony and Silesia. These ores occur in small proportions in several of the famous old mines of Europe. Their production has been small, however, and was in proportion to the consumption of cobalt oxide, for the ores were not so very high in silver. About six years ago ores of the same general character, but phenomenally rich in silver, were discovered in quantity in the northern part of Ontario. The mines of the so-called "Cobalt District," where well-located and well-managed, have been exceedingly profitable and now furnish 12 per cent of the world's silver production. The silver is present in such large amounts (about 3 per cent on the average—and it must be remembered that copper ores of less than 3 per cent can be a source of profit nowadays) that the other valuable products can be neglected, and have been neglected, commercially for some years. The course of treatment used by the principal purchaser of these ores, the Orford Copper Company, is roasting and smelting in short, small blast furnaces. From these operations three products are produced: first, a crude arsenic oxide which is refined by a volatilizing roast; second, a crude silver bullion, "800 to 850 fine," which is sold to the silver refiner, and, third, a speiss containing approximately 20 per cent cobalt, 10 per cent nickel and less than 1 per cent silver. This speiss is roasted and subjected to a chemical process for the production of fine silver, refined nickel oxide, and refined cobalt oxide. The principal source of revenue to the mining company is, however, silver.

Naturally, the increase in production of these ores has resulted in a glut in the market for cobalt oxide and arsenious oxide. An analysis of the reports of the four principal companies shows that they are producing silver for less than 20 cents per ounce. Consequently the by-products are not playing, as yet, any great commercial rôle. Indeed, some of the ores are smelted in the lead blast furnace for the silver alone and the other three constituents wasted. And in general arsenic oxide is now selling for one-half of its usual price and cobalt oxide for less than one-third of its former price.

However, in this complex modern civilization of ours the uses and needs of industry are many and varied. And the old law of economics that low prices stimulate consumption and extremely low prices increase consumption by finding new uses for the commodity seems now in this instance to be operating with rapidity and certainty. With the low prices of arsenious oxide, the demands for the fungicides of which it is the base have been increased. Especially is this true of lead arsenate, which is used by the fruit growers of this country to kill the San José scale and other deleterious parasites. The market for cobalt oxide is also steadily increasing. It has been long known that mixed, 1 part to 10,000 parts, with china clay cobalt oxide gives to the ceramics a blue cast that neutralizes the yellow cast formed by the oxide of iron. It is almost humorous to consider that the laundress uses bluing in the water for a similar purpose. Naturally, when the price is low, potteries use more cobalt oxide and produce dead-white pottery cheaper.

Cobalt, when in the metallic state, is a great hardening constituent of alloys and has been found to produce alloys of different and superior qualities to those alloys where its twin chemical brother replaces it. Furthermore, cobalt oxide can be made the base of several blue or green mineral pigments. The low price of cobalt oxide has stimulated chemical research in several lines looking to new commercial uses for cobalt and cobalt oxide. This work is eventually sure to find new and permanent applications. Increased permanent consumption will give stability to the industry. Production will be increased to meet future requirements. The veins of the Cobalt District can be characterized as rich, narrow, and short. Hence, the cost of development is sure to increase at depth, for prospecting can no longer be done by cheap surface trenching. For the future the camp must look to the low-grade ores with values in by-products for the profits. A similar evolution has been experienced in Leadville, where the once-despised zinc-sulphide ores are a large source of profit. The metallurgical treatment of these ores and the working up of the resultant by-products by chemical methods present a field actually fascinating and potentially profitable to the research chemist.

Program of Chicago Meeting of American Electrochemical Society.

The eighteenth general meeting of the American Electrochemical Society will be held in Chicago from Oct. 13 to 15 (Thursday to Saturday). Hotel headquarters will be at the Congress Hotel (Auditorium Annex).

The morning sessions of Thursday and Friday will be held in the Florentine Room of the Congress Hotel, the morning session of Saturday at the Kent Chemical Laboratory of the University of Chicago.

For the afternoons a number of highly interesting alternative excursions have been arranged as follows:

Thursday Afternoon.—Union stockyards and the packing plants of Swift & Company, Armour & Company and Morris & Company;

Or, Fisk Street power house and Market Street transformer and storage-battery station of the Commonwealth Edison Company;

Or, the telephone factory of the Western Electric Company;

Or, the factory of the Automatic Electric Company (automatic telephones), Market Street storage-battery station of the Commonwealth Edison Company, and demonstration exhibit of electric furnaces of the Hoskins Manufacturing Company.

Friday Afternoon.—South Chicago works of Illinois Steel Company (with 15-ton Héroult electric steel furnace);

Or, Gary steel works at Gary, Ind.;

Or, Sears, Roebuck & Company and the Washington and Franklin Streets exchanges of the Chicago Telephone Company.

Saturday Afternoon.—Laboratories and museums of the University of Chicago, and Field Columbian Museum;

Or, Lockport power station and drainage canal.

A special and very attractive program has been arranged by the ladies' committee for the entertainment of visiting ladies.

On Friday evening a subscription dinner will be held at the Congress Hotel.

The following is a list of the papers which will be presented and discussed at the professional sessions:

Method for determining thermal conductivity. By Carl Hering.

Heat flow through electric furnace walls. By F. T. Snyder.

The Hiorth electric steel furnace. By Jos. W. Richards.

Cast copper of high electrical conductivity. By. E. Weintraub.

The electric furnace and its applications. By Marcus Ruthenburg.

Electrolytic method of producing metals. By John W. Beckman.

Reduction of tin dross in the electric furnace. By R. S. Wile.

Notes on tribo-luminescence. By W. S. Andrews.

The proximate constituents of the chemical elements with reference to radioactivity and electrons. By Gustavus D. Hinrichs.

Electrochemical preparation of calcium. By A. R. Johnson.

Efficiency in the electrolytic preparation of calcium. By Francis C. Frary, Henry R. Bicknell and Carl A. Tronson.

Electrochemistry of polonium and other radioactive elements. By A. R. Johnson.

The present status of ozone. By R. D. Small.

The evolution of the lead storage battery. By Pedro G. Salom.

A new secondary cell. By W. S. Block.

The self-discharge of Plante and Faure storage batteries. By O. W. Brown and W. G. Bowers.

Corrosion of metallic food containers—causes and prevention. By Edward Gudeman.

Electrolytic corrosion of various metallic anodes in a liquid ammonia solution, ammonium trinitride. By A. W. Brown, M. E. Holmes and J. S. King, Jr.

Electrolysis of solutions of ammonium trinitride and of potassium amide in liquid ammonia. By A. W. Brown and M. E. Holmes.

On the electrolysis of some cyanides. By H. E. Patten and W. R. Mott.

Application of electrostatic separation to ore dressing. By F. S. MacGregor.

The isolation of an ion and a precision measurement of its charge. By Robert A. Milliken.

Phenomenon of crystallization through membranes. By J. H. Walton, Jr.

On the relative basicity of the metals as shown by their power to replace one another in chemical compounds. By L. Kahlenberg.

On the effect of water in causing chemical reactions. By David Klein.

The physical and magnetic hardness of some electrolytic iron alloys. By James Aston.

Dr. William H. Walker, of the Massachusetts Institute of Technology, is president; Dr. Joseph W. Richards, Lehigh University, South Bethlehem, Pa., is secretary of the American Electrochemical Society.

Prof. H. N. McCoy is the chairman and Mr. Arva B. Marvin is the secretary of the local Chicago committee.

The Western Metallurgical Field.

Copper.

The report of the Copper Producers' Association for August, issued Sept. 8, showed a reduction in surplus stock of 1,759,433 lb. as compared with the figures for July. This is the first reduction that has been noted for many months. During May the surplus was increased by 18,411,814 lb.; during June by 7,960,044 lb., and during July by 2,255,661 lb. Inasmuch as the effects of curtailment in production begun in August had not had time to affect the situation the condition is regarded as favorable.

The August production of some of the Western mines and reduction works was lower than usual. In Butte the Clark properties were closed down, with a consequent reduction of 1,250,000 lb. of copper, being the largest part of the total reduction in Butte mines of 1,646,280 lb. as compared with July. The total production of Butte mines for August was 317 210 tons of ore containing 21,724,100 lb. of copper. At Ely, Nev., one of the four units of the concentrator of the Steptoe Valley Smelting & Mining Company, at McGill, was closed, and the production of ore at Copper Flat was reduced from 8000 tons or 9000 tons per day to 6000 tons or 7000 tons. The reverberatory capacity of the smelter has not been reduced, however, and four furnaces are still being operated at full capacity. The Yampa smelter, at Bingham, Utah, also closed Aug. 1, but the ore that was treated at this point will be diverted to other Utah smelters, so that the closing of the plant will have little effect on the output of copper.

In the meantime the plant of the International Company is coming forward, matte having been tapped and converted late in August. It is also reported that the Garfield smelter is to be enlarged to handle the increased output of the remodelled mills of the Utah Copper Company. New reverberatories, flues and a new stack are to be added to the present plant. All of this will not be completed for some months, probably a year; but when completed the plant will be one of the largest in the West, having a capacity of 16,000,000 lb. per month. The new copper properties—Miami, Ray and Chino—will probably come forward slowly, so that when they have entered the list of producers the demand for copper probably will have increased so that their output will be absorbed readily.

Statistics on cost of copper production have been issued by most of the large companies, and some of them have shown remarkably low costs. It has remained for the Kennett (Cal.)

Works of the U. S. Smelting, Refining & Mining Company to show a cost of 4½ cents per pound for copper made there. This figure is arrived at by taking into consideration the gold and silver value in the ore treated, and as this is higher than in most ores, the effect on cost of production is more marked.

Important Tailings Suit Decision.

About six years ago suits were instituted by the ranchers along the Coeur d'Alene River against the mining and milling companies of northern Idaho, praying for relief from the effects of dumping tailings in the river, whereby it was claimed that the river bed was filled with debris causing the water to overflow the banks and damage the adjoining lands. In all, 65 suits were filed against the various companies, and damages aggregating $1 233,000 were claimed.

Recently one of the cases has been decided by Judge Dietrich in the Federal Court at Moscow, Idaho, by awarding $1 damage to nine plaintiffs, and dismissing the suit. A striking feature of the case was the fact that the defendant company, the Bunker Hill & Sullivan Mining & Concentrating Company, introduced no evidence, and the court concluded that the plaintiff had not shown sufficient evidence to warrant further consideration. The decision is of great importance to the Coeur d'Alene district, as it will settle a vexed question unless it is reversed by the Court of Appeals.

Mexican Institute of Mining and Metallurgy.

A general meeting of the Institute was held in Mexico City on Sept. 13 commemorative of the first year's work. President A. Grothe reviewed the results accomplished, and a number of interesting papers were read. This young Institute has met with a favorable reception at the hands of engineers in Mexico, and the *Informes y Memorias* published have reflected the interest shown. Mexico has presented metallurgical problems different from those usually met with, and it has been the aim of the Institute to foster a unity of interest among professional men and disseminate information that would enable them to solve their problems quickly.

As an example of the excellent metallurgical work done on silver ore in Mexico we quote the following from the last bulletin, Vol. 1, No. 6, referring to the plant of the San Rafael y Anexas Company, of Pachuca: "Prior to 1909 about 1000 grams of silver per ton were required to cover mining and milling charges. Since cyaniding was adopted from 300 grams to 350 grams per ton will pay for all costs, and 500,000 tons of ore, half in the filling and half on the dump, averaging some 500 grams, have become available at once and will be milled with a good profit. Since the mill was started in 1909 we have been short of power and for this reason forced to curtail the production and to resort to an expensive sorting in order to improve the value of the ore milled, raising the cost of production." The average assay of the ore treated is given as 888 grams silver and 4.08 grams gold. The waste from the sorting runs from 166 grams to 300 grams silver. Cost of milling, $4.04 (Mexican) per ton.

The mill was described in detail in Institute Bulletin No. 3, Vol. 1, but since then the capacity has been increased and the plant improved so that at present it treats from 400 tons to 500 tons per day, according to the class of ore handled. The silver extraction recently has been raised to 94 per cent and the gold to 96 per cent, the cost per ton being as stated above. The equipment of the mill comprises in the main the following: 3 Blake crushers, 9 x 15; 1 set of rolls, 36 x 16; 80 stamps; 18 tables; 7 Dorr classifiers; 7 Dorr pulp thickeners; 7 Krupp tube mills; 12 Pachuca tanks, 15 ft. x 45 ft.; 3 Moore filter units, each with 80 10 ft. x 6 ft. leaves.

Cyaniding in Colorado.

There is a marked tendency to favor the cyanide process in Colorado in the treatment of both old and new ores. The success of the Golden Cycle mill treating Cripple Creek ores by roasting and cyaniding, and the application of cyaniding to the chlorination tailings of the Portland and Standard mills has directed attention to the possibilities of the process. The new Portland and Independence mills at Cripple Creek, treating low-grade mine ore and dump ore respectively, are in successful operation on material worth about $3 to $4 per ton. More recently, however, tests on ores from other districts have proved that the process may be extended to the treatment of sulphide concentrates and raw silicious sulphide ores. In the Georgetown district an old stamp-concentration mill is being remodeled into a cyanide plant for the treatment of the raw ore. Reports from the vicinity of Breckenridge indicate the possibility of gaining 90 per cent extraction from ores that are not now treated, although roasting will have to be used in connection with cyaniding on these ores. Other experimental work on Boulder and Black Hawk district ores and concentrates indicate the success of the process.

Colorado has, for so many years, been a smelting center that many mine owners were loth to listen to suggestions of other methods for treating their ore, and made few attempts to work out a treatment method if smelting could not be made to pay. This attitude is changing, however, and while smelting will continue as a means of treating a large tonnage of Colorado ore, the smelters are now on reduced supply and the outlook is not bright for an increase.

Leadville Zinc.

The recent report of the discovery of bodies of zinc carbonate in a number of Leadville mines has attracted attention to the possibilities of a new era in Leadville mining and metallurgy. Sulphides of zinc have for some years been mined and treated by magnetic separation methods, but within a short time carbonates of zinc has been found in the Maid of Erin, Adams, Wolftone, Mahala, Henriet, Morning Star, Waterloo, Chief, and other old Leadville mines. The report is to the effect that active production will commence in some of these properties very soon. The grade of the zinc carbonate discovered is reported to be from 25 to 40 per cent zinc.

Non-Ferrous Metal Market.

The September market for non-ferrous metals was almost without feature. Prices for copper and lead have remained almost stationary, but spelter has experienced an advance and holds a better position than for some time, with prospects of further improvement. Tin was subject to a slight rise during the early part of the month, but has receded to a lower level.

Copper.—With the exception of the export trade there has been little important business transacted in this metal. The refinery statistics for August naturally did not show the effect of the curtailment of production which is under way, and consumers were not moved to purchase more than for immediate use. The market has been almost stationary at 12.5 cents to 12.75 cents for lake and 12.35 cents to 12.45 cents for electrolytic. Lake copper has been especially stagnant.

Lead.—Quotations remained unchanged at 4.40 cents, New York, and 4.27 cents to 4.32 cents, St. Louis. Transactions have been of the usual volume, but the demand is easily met.

Zinc.—This metal has improved its position materially during the month and the prospect is for a still better market. Quotations advanced during the month and a good volume of business was done, as both producers and consumers appeared to have little surplus stock. New York quotations advanced to 5.55 cents to 5.60 cents, and St. Louis to 5.40 cents to 5.45 cents.

Tin.—The domestic market was affected early in September by speculation in London, and for a brief time the domestic market showed an advance. Consumers were apparently little concerned with the reported London corner, and declined to buy Straits tin at the premium usually asked. This resulted in the use of other grades, with the result that it is

possible other brands will be used more extensively in the future to the disadvantage of Straits metal. The New York quotations for September tin declined to 34⅜ cents.

Other Metals.—Aluminium and antimony markets were rather quiet during the month. Quotations on the former were 22 cents for No. 1 ingots, and on the latter stationary at 7¼ cents to 8¼ cents for various brands. The quicksilver market was somewhat improved, but prices remained unchanged at $46 per flask of 75 lb. in large orders, with advances for smaller lots.

The Iron and Steel Market.

Production of iron and steel has proceeded at a practically uniform rate during September, gaged by pig iron being made at the rate of about 24½ million tons a year. The high point in production was in February, with a rate of fully 31½ million tons, but this represented an unhealthy spurt, for, while general business conditions were not as good as in 1907, the maximum rate attained in that year had been 28 million tons.

September opened with better buying of finished steel products and better specifying upon old contracts. About the middle of the month rumors became thick that there was extensive shading in a number of products and that a radical reduction was in contemplation by leading interests as a rejoinder. In well-informed circles these reports were recognized at the time as unfounded, for while there was some cutting, there was no more than there had been through the first half of the year, when nominal prices were continually receding. The difference in position, if any, was that in the earlier period cut prices once made soon became the market, whereas a determined stand was being made by leading interests, dating from early August, to maintain plates, shapes and bars at $1.40, Pittsburgh. Attention was given to the rumors to such an extent that a meeting was held in New York September 21 of officials of the United States Steel Corporation and the principal independents, apparently for the purpose of considering whether an open reduction should be made. The meeting developed no disposition to reduce prices and as a result no change occurred.

The present price position is, that steel bars are held quite uniformly at $1.40, Pittsburg, against $1.45 on January 1, when the general level was highest; plates and shapes are held by the leading mills at $1.40, Pittsburg, except that occasionally on large structural contracts shapes are shaded, perhaps by several dollars a ton, with shading of plates by a few mills of $1 to $1.50 a ton and other products are selling at open market prices. Taking extreme prices in all cases, it can easily be shown that the general level of finished steel prices has declined at a slower rate since August 1 than from February 1 to August 1, for indeed there has been very little recession in the past two months.

On the whole September has been a better month for business than August, but bookings have nevertheless fallen quite short of shipments and this deficit is becoming serious for the reason that certain lines in which there has been little new business lately, but full production, are reaching the end of the accumulations. This observation applies particularly to rails, fabricated steel and steel cars. The slackness of orders along these lines has not been felt because of the large accumulation of business, but it has now become clear that without a large augmentation of new business a further decrease in production of primary materials will be necessary in the near future.

What is called political uncertainty is generally referred to as the chief drag upon business, but the term appears to be a misnomer for it is difficult to see how the different parties promise substantially different things. Perhaps it will be found to have been more accurate to regard the present as a period of readjustment after too great a swing in the recovery from last year's breaks in prices.

Pig Iron.

A few important sales of pig iron in August gave rise to expectations in some quarters that a general buying movement would be precipitated. These expectations have been disappointed. The market has continued to drag, although the total volume of sales has probably shown a slight increase. A disappointment has been furnished by producers discovering that consumers are better covered for this year's delivery than was assumed. In the case of Southern iron, in particular, a sharp line is drawn at Jan. 1, consumers being very well covered to that date, but having bought practically no iron for delivery beyond it. With Northern iron the same distinction can be made, but the line is hardly drawn as sharply. Roundly speaking, prices of pig iron are about 25 cents lower than at last report. In the valley-Pittsburgh district there are some evidences that a halt has at last been called upon the decline. Bessemer iron, which sold at $15, valley, at the beginning of the month, remains at that figure, and there have been a number of purchases at the price, even for first quarter delivery. Basic has declined to $13.50 valley, a price which is well below cost of production to furnaces buying ore, and the decline to this point seems to have been caused by the existence of large stocks. When the cost line has been reached a spread of $1.50 between basic and Bessemer is unnatural and as Bessemer appears established at $15 for next year basic promises an advance. There are no sellers beyond the present quarter at $13.50, valley, and it is questionable whether even $14 could be done. Foundry iron has continued at $14, valley, forge being $13.25 and malleable $14. Southern iron is not strong at $11, Birmingham.

Steel.

The market for unfinished steel has been disturbed by producers removed from Pittsburgh selling at delivered prices lower than the Pittsburgh basis, plus freight to destination. Occasionally also middlemen shade the regular basis with steel obtained through conversion deals. The Pittsburgh basis, from which there are occasional deviations, is substantially $24.50 for Bessemer billets and $25.50 for open-hearth, with $1 advance for sheet bars. Rods are quotable at $28, Pittsburgh.

Finished Products.

Sheet prices have continued to decline, concessions from the nominal basis reaching $5 a ton on black sheets, $6 on galvanized and $3 on blue annealed, compared with $3, $5 and $1 a month ago. We quote net prices in the list below. Narrow plates have become definitely quotable at $1.35, while $1.40 continues as the usual quotation on wide plates, with occasional shading. Wire products and merchant steel pipe are being rigidly held at former prices, and the demand is good, better than for any other finished steel product. Pressure for tin plate deliveries has been heavy in September, chiefly on account of an exceptionally heavy demand for the corn crop, while buying for winter requirements by the steady consumers has been light, and in order to stimulate the market now that the canning demand is over it is not improbable that a reduction of perhaps 15 cents a box will be made some time in October.

We quote the market as follows, Pittsburgh unless otherwise noted:

Standard steel rails, $28 at mill, except Colorado.

Plates, $1.40 for wide, $1.35 for narrow, tank quality, ¼ in. and heavier.

Shapes, $1.40 for beams and channels, 15 in. and under, zees, and angles 2 x 3 and larger.

Steel bars, $1.40, base; iron bars, $1.45, Pittsburgh; $1.35, Chicago; $1.35 to $1.40, Philadelphia.

Wire nails, $1.70, base; plain wire, $1.50; painted barb wire, $1.70; galvanized barb wire, $2.

Black sheets, 28-gage, $2.15 to $2.20; galvanized, $3.20 to $3.25; blue annealed, 10-gage, $1.60 to $1.65.

Tin plates, $3.60 for 100-lb. cokes.

Institute of Metals.

The autumn meeting of the (British) Institute of Metals, devoted to the metallurgy of non-ferrous metals, was held at Glasgow from Sept. 21 to 23 under the presidency of Sir Gerard Muntz.

The program included excursions to various works of metallurgical interest in Glasgow and vicinity and an all-day trip on the Clyde, visiting the Isle of Arran and the Kyles of Bute.

In the following we give abstracts of two of the papers presented, prepared from advance copies. The balance will be abstracted in our next issue.

Mr. G. Shaw Scott, Caxton House, Westminster, S. W., London, is the secretary of the Institute of Metals.

Metallography in the Brass Foundry—Gunmetal Castings.

The paper by Mr. H. S. PRIMROSE, metallurgist to Messrs. G. & J. Weir, Ltd., of Cathcart, deals with "metallography as an aid to the brass founder." The microscopical investigation of the structure of alloys is largely superseding the method of judging quality by fracture, and is undoubtedly a more certain guide to the foundryman who wishes to escape the repetition of serious failures due to causes other than change of chemical composition.

The usual standard to which most foundries have to work is governed by rigid specification of the tensile strength and elongation of test bars from the castings produced, and while this method affords a valuable check upon the acceptance of faulty workmanship, failure generally results in throwing the onus onto the metal, but most cases of microscopic examination reveal the fact that structural deficiencies are to blame.

The ultimate strength and degree of elongation which a metal possesses depends entirely on the nature of the crystalline arrangement, and this, in turn, depends upon the rate of solidification, as also to a less extent on the rate of cooling after solidification. For each metal or alloy there is a certain size and arrangement of crystal grain which gives maximum strength and durability. If this be exceeded, then there is not sufficient interlocking of the crystals and thus large cleavage planes are formed, but if the crystal grain be too small, the interlocking may be so minute as to be almost valueless.

The author gives a series of microphotographs of gunmetal species taken from test bars which were attached to actual castings and subjected to tension to determine tensile strength and elongation. The composition of the specimens was that of the usual Admiralty gunmetal, viz., 88 per cent copper, 10 tin, and 2 zinc. The castings were made in dry-sand molds and as nearly as possible all under the same condition of cooling.

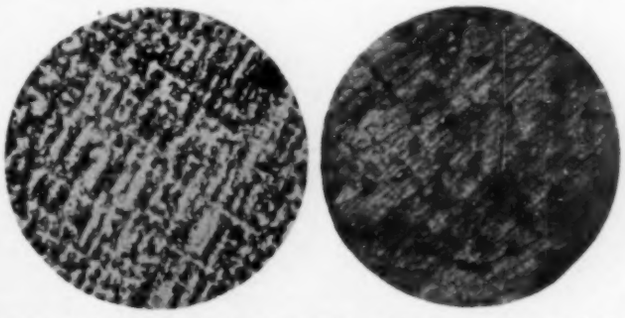
With gunmetal castings the temperature of pouring has a great influence on the strength of the finished castings. In the case of the pouring being at a high temperature, just before freezing commences, the sand of the mold becomes highly heated and so the freezing of the metal is slower than when the metal is not so hot at first, and hence the crystals have time to grow and form a good, strong interlocking structure. This is shown by the microphotograph of a test bar from a casting poured at 1100° C. and slowly cooled (Fig. 1). A similar bar cast at a much lower temperature (950°) was cooled much more quickly and in this instance the crystals not only have been prevented from growing, but the constituents of the metal have remained practically in a state of solid condition with no well-defined structure which is seen to be unresolved (Fig. 2) even with much higher magnification (150 instead of 6[illegible] diameters). With the quick, uniform contraction of the solid solution, intercrystalline pores develop and the resulting casting is porous and weak.

This is of great importance for castings which have to stand the test of high water pressure so that the temperature of pouring such castings has to be carefully watched. Further, to get the same quality in all castings, the metal for large and thick castings should not be so highly heated when cast as that which is used for much thinner work. Thus the casting temperature of gunmetal is not a constant, but must necessarily vary with the weight of the casting, as well as its internal and external form, and the number of branches, arms, and projecting parts on the casting.

Now if the founder is careful, and bears this fact in mind, many difficulties can be overcome by arranging his molds of dissimilar castings so that those of a light nature are cast first with hot metal. It is evident that by using a ladle a great variety of casting temperatures can be got, and occasional pauses may be made between some of the molds if the temperature is too high for the nature of the work.

The existence of blow-holes in gunmetal weakens the castings to a very considerable extent. The presence of the blow-holes may be due either to slight dampness in the mold when the metal is cast into it or the gases which form these holes may be actually dissolved in the metal when it is cast. They are often a great source of trouble to the founder, but a microscopical examination is the surest way of ascertaining the cause of blow-holes. If these are clean and confined to the outer portion of the castings they are certain to be due to the steam formed within the mold, in which case a simple remelting brings the metal right.

More often the pinholes in castings appear dirty under the microscope, and on polishing, some brittle material is rubbed



FIGS. 1 AND 2.—MICROPHOTOGRAPHS SHOWING EFFECT OF TEMPERATURE OF POURING.

out, causing serious scratching of the surface. This is due to segregations of included oxides either of tin or copper, which the small percentage of zinc has not been able to remove. Under this condition remelting is of no avail unless with the aid of some deoxidizing agent, such as phosphor tin or phosphor bronze. This need only be added in very small proportions, and which of these is employed will depend on whether the copper or tin is deficient. Their action is due to the phosphide attacking the dissolved oxides, reducing them to metal, and the phosphorus escapes as pentoxide.

It is not often that gunmetal is cast from large furnaces or ladles, but when this is done in large workshop practice special precautions must be taken to ensure the uniformity of the metal from beginning to end of the cast. Segregation does not so readily take place, but with a great weight of metal in the ladle some scum and dirt is apt to be intermixed; the removal of this is somewhat troublesome, even with stirring and the addition of deoxidizers unless a billet of green wood is used to agitate the metal. The stirring is sometimes done by a so-called "secret process," which consists in stirring the metal with an iron rod to the end of which an ordinary potato is affixed.

While the pyrometer is of great service in determining the temperature of the metal before pouring, it is not practicable to take the rate of cooling of each casting. Hence it often occurs that perfectly sound metal gives test bars which fall just short of the required strength, and the reason for this is another point easily explained by the microscope. One of the microphotographs of the author shows that the copper crystals have grown too rapidly in certain directions and thus the

required amount of intertwining has not been effected, with the result that the strength is somewhat low. Another microphotograph shows a rather fine-grained structure almost devoid of interlocking. The author thinks it likely that a suitable annealing would have promoted diffusion and brought the strength of these two castings up to a very much higher standard.

Comparison of microstructures very quickly enables the necessary experience to be acquired for determining the cause of troublesome defects should such occur, and this is more than half the battle in the direction of putting things right again.

Magnetic Alloys from Non-Magnetic Materials.

A paper by Mr. Alexander D. Ross deals with "magnetic alloys formed from non-magnetic materials." The author tested especially the following ternary alloys: Copper-manganese-aluminium; copper-manganese-tin; copper-manganese-antimony; copper-manganese-bismuth, and the following binary alloys: Copper-manganese; copper-aluminium; manganese-antimony; manganese-boron. As to the magnetism of the copper-manganese-aluminium alloys (Heusler alloys), the author adheres to his former view that the magnetic properties are due to the formation of solid solutions, of which the compound Cu^2Al is a constituent.

CORRESPONDENCE.

Defects in Refractory Brick.

To the Editor of Metallurgical and Chemical Engineering:

Sir:—I have read Mr. Bailar's letter on the above subject in your issue of September, 1910.

I entirely endorse what he says about shapes. The natural surface of a pressed brick is one of its best assets. Once that has been chipped or even ground off the brick has deteriorated.

Mr. Bailar announces that he is about to take up arms in defence of the manufacturer, and two paragraphs further on proceeds to hit him over the head with his own brick. I fully agree that when a purchaser does not know what he wants he cannot complain if he doesn't get it. Anyone who orders bricks of a certain chemical composition, regardless of their physical properties, can be added to the foregoing class.

What I am complaining of is this: When the physical and chemical properties of the brick required have been carefully stated and samples submitted showing that such bricks can be manufactured and are not unsubstantial ideals and when the increased cost has been agreed to, that the net result of all the trouble and discussion and investigation on the part of the consumer should be all too frequently one or more carloads of "firebrick" (the quotation marks are taken from Mr. Bailar), showing little or no evidence that the consumer's carefully formulated requirements have been appreciated or that any serious attempt has been made to meet them.

Some day, I suppose, the condition of things refractory will be as described in Mr. Bailar's last sentence. But so far as I am aware the time is not yet.

New Jersey Zinc Company, Gilbert Rigg.
Palmerton, Pa.

Electric Steel Making in Spain with Utilization of Slag.

To the Editor of Metallurgical and Chemical Engineering:

Sir:—As your journal has covered in detail the progress of the electrometallurgy of iron and steel in various countries, the following data on developments in Spain should be interesting, especially as little has so far been published about them.

Although the iron and steel industry of Spain is of small importance compared with that of other countries, yet there are several plants in a prosperous condition, particularly in the north of Spain.

Among these establishments one of the best known is the Viuda de Urigoitia e Hija, its products being well known all over the country for their excellent quality. The works, located at Araya in the province of Alava, are ably managed by the brothers C. and J. de Ajuria, two metallurgical engineers who have kept themselves thoroughly acquainted with all new metallurgical developments.

In the early days of the electric steel furnace they installed at Araya a Kjellin induction furnace, but after various attempts and some weeks of operation, it was practically abandoned. They then decided to install a simple resistance furnace and selected the Louvier-Louis type. Some six months ago a 225-hp furnace of this type was installed at Araya, and since its erection it has worked without interruption and to the complete satisfaction of the owners.

Common scrap iron of all kinds is used as the raw material. To produce in the 160-kw furnace 1210 kg of high-carbon steel (containing 1.03 per cent of carbon) 970 kw-hours are consumed, i.e., 802 kw-hours per metric ton (2200 lb.) of steel produced, starting with cold raw materials.

In the production of 1230 kg of soft steel, the consumption of electrical energy is 795 kw-hours, or 646 kw-hours per metric ton produced.

As these results are obtained in a furnace of small size, it may be estimated that in a 5-ton furnace the electric power consumption would be reduced by, say, 25 per cent.

However, the efforts of Messrs. de Ajuria have not been limited to economic steel production in the electric furnace. They have employed their electric steel furnace also for other purposes. Assisted by the inventors of their steel furnaces, principally by Mr. Louis, they decided to use their Louvier-Louis furnace for the working-up of the slag which had accumulated in their yards from the operation of their blast, reheating and puddling furnaces. Until then this slag had simply been a waste, had occupied valuable space, and obstructed traffic and transportation.

It was now decided to try and utilize this slag for the manufacture of ferrosilicon and of a superior grade of cast iron in the electric furnace; the ferrosilicon to be sold and the cast iron to be used in the works for the casting of special pieces.

Although the Louvier-Louis furnace was designed for steel making, it proved very satisfactory for these new purposes. The results were as follows:

Ferrosilicon.—Two grades of ferrosilicon were made, one containing from 25 per cent to 30 per cent silicon, the other from 50 per cent to 60 per cent silicon.

In every trial a comparison was made between the use of coke and charcoal as reducing agent. The results were in all cases in favor of charcoal.

In the manufacture of 25 per cent to 30 per cent ferrosilicon the raw materials were slag from the reheating furnace and coke or charcoal in dust or small pieces. In the 160-kw furnace the manufacture of 1 metric ton of ferrosilicon required 3790 kw-hours using coke, and 3445 kw-hours, using charcoal.

In the manufacture of 50 per cent to 60 per cent ferrosilicon the raw materials were slag, to which had been added silicious ore from the vicinity of the works, and coke or charcoal. The power consumption per metric ton of ferrosilicon was 8030 kw-hours using coke, and 7105 kw-hours using charcoal.

It will be seen that the use of charcoal represents a considerable economy in electric power consumption. Moreover, the operation of the furnace was better, the chemical reduction easier, and the volatilization of the silicon almost nihil, beside a smaller consumption of electrodes.

Cast Iron.—For the manufacture of cast iron in the 160-kw electric furnace slag from the puddling furnace was employed as raw material. The power consumption per metric ton of cast iron was 1660 kw-hours using coke and 1485 kw-hours using charcoal as reducing agent.

This consumption of 1485 kw-hours per metric ton is equivalent to 0.229 hp-year per metric ton, which is a very low figure for a small-size furnace. For a large-size furnace the consumption would be considerably reduced.

Mexico City, Mexico F. L.

The Passing of Crucible Steel.

BY JOSEPH W. RICHARDS.

A prominent American mechanical engineer on returning from Germany declared that the Germans were 15 years ahead of the United States in some mechanical engineering work. In similar vein, let us freely admit that in the manufacture of fine steel the Germans are at least five years ahead of us, for five years ago the Remscheid plant, about to be described, shut down its crucible steel furnaces and installed in their place the Héroult electric furnace for the manufacture of all varieties of fine steels, up to the finest, while our own Crucible Steel Company of America is only just now waking up to the situation and commencing this year to "do likewise."

The members of the Fifth International Congress for Mining and Metallurgy, held this summer at Düsseldorf, were invited to visit the works of the *Stahlwerke Rich. Lindenberg, Aktien Gesellschaft*, at Remscheid-Hasten, and every opportunity was

FIG. 1.—VIEW OF OLD STEEL WORKS.

given the visitors to make themselves fully familiar with the manufacture of steel as there carried out. The entire absence of secrecy was a most convincing demonstration of the industrial strength which comes from being first in the field, and keeping ahead of competitors not by secrecy, but by sheer force of superior enterprise and workmanship. Nine times

FIG. 2.—VIEW OF THE WORKS IN 1908.

out of ten industrial secrecy is an index of industrial weakness; the really strong have no need to shut themselves up in industrial fortresses, but can act large-mindedly, conscious of their innate strength.

We will give first the general plan and description of the works as a whole, and then follow with a detailed description of the electric furnace work. Some of the information and illustrations are taken from *Deutsche Industrie-Deutsche Kultur*, Vol. VI, No. 7; the larger part is from our own direct observation.

History of the Lindenberg Works.

The firm of Gebr. Lindenberg & Company was founded in 1840-41 by Albert, Richard, and Ewald Lindenberg, and within

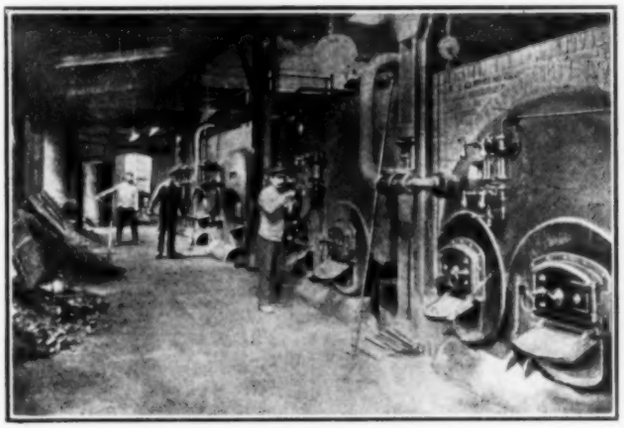


FIG. 3.—BOILER HOUSE.

a short time its fine steel, bearing the trade-mark "Glocke," was well known all over Germany and in almost all countries of Europe. At this time the German steel industry was just beginning to free itself from English domination, but for many years the steel bars and ingots were still brought from England. In 1864, however, the firm commenced to make its own crucible steel, and this part of its business was carried on under the name of the Stahlwerke Rich. Lindenberg, Aktien-Gesellschaft.

The erection of the first crucible works, with steam hammers

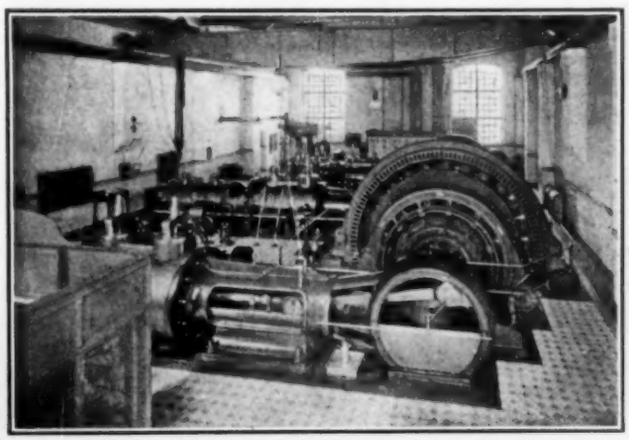


FIG. 4.—ELECTRIC GENERATING PLANT.

and rolls, was a difficult undertaking, for all the materials and machinery had to be hauled over mountain roads from Elberfeld, four miles distant, and it was only in 1868 that the works had railway connection with the rest of Germany. An early specialty of this works was "Damask spring steel" for railway car springs, which attained great popularity, and was used for 30 years for this purpose, in competition with open-hearth steel, in spite of its much higher price.

There was much difficulty, however, in those early years, in inducing German steel workers to give up buying English steel; their prejudices against German-made steel were only slowly and laboriously overcome. In 1896 the old crucible melting holes were replaced by two 24-crucible regenerative gas furnaces. In 1899 Rich. Lindenberg, Jr., became head of the works, which in 1901 he changed to a limited stock company.

In 1904 this firm was the first German works to take up the question of manufacturing its steel electrically, and in December, 1904, concluded to erect two experimental Héroult furnaces of ½ ton and 1½ tons capacity. These, with the necessary power plant, were erected in 1905, from plans of Director Rich. Eichoff (now professor of metallurgy in the Imperial Mining Academy in Berlin), and the first charge of electric steel was poured on Feb. 17, 1906. Since March 23, 1906, the two electric furnaces have been in uninterrupted service.

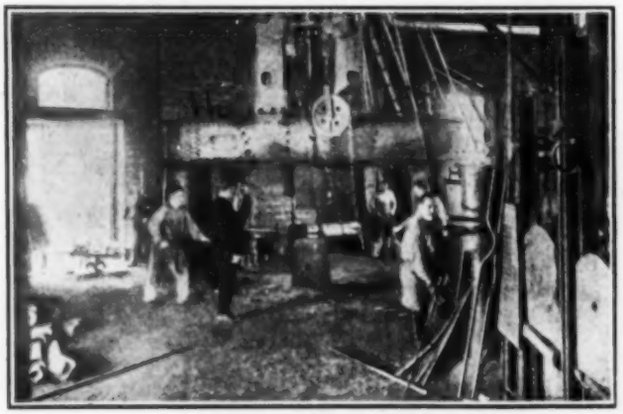


FIG. 5.—5-TON HAMMER WORKING A 1-TON ELECTRIC STEEL INGOT.

The steel thus electrically manufactured was so advantageous in regard to quickness of production, easy work, protection of the workmen, and above all in superior quality of product, particularly for tool steels, that inside of a year the demand had far exceeded the capacity of the plant, and in 1907 a third electric furnace of 3 tons capacity was installed, the power station increased to 1600 hp, a larger roll train put in, and a special department for making magnets started. The firm was also reorganized to its present constitution by German and Swiss capitalists, with a capital of 2,250,000 marks ($550,000).

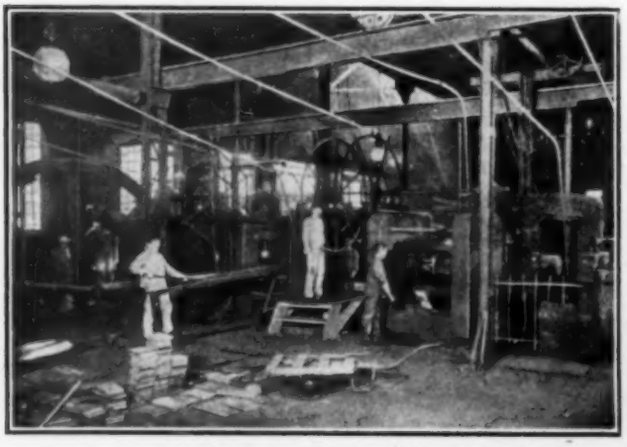


FIG. 6.—ROLLING SAW BLANKS.

General Description of the Works.

The steel-making building is 15 m by 60 m (50 ft. x 200 ft.). At its one end is a tilting open-hearth furnace of the Wellman construction, basic hearth, capacity three tons, served by two gas producers outside the building. Next to it are two Héroult electric furnaces, each with two electrodes, single-phase, run by two transformers in parallel; the smaller is acid hearth, capacity 1.5 tons to 1.8 tons; the larger is 3 tons capacity, basic hearth of burned dolomite. The liquid metal from the open-hearth furnace is transferred to the electric furnaces. The whole installation produces 40 tons to 50 tons per day—12,000 tons to 15,000 tons per year.

The power requirements were not easily met, since there is no cheap water-power in the neighborhood, no waste blast-furnace gases, and freight on coal from the Rhein district is high. The boiler house (Fig. 3) has six boilers with a total heating surface of 1000 sq. m (35,000 sq. ft.), giving steam at 10 atmospheres (150 lb.) pressure. The power house (Fig. 4) has one 1600-hp, four-cylinder, twin-tandem steam engine, running two dynamos on one shaft, the one a direct-current machine of 570 kw, at 450 volts, for running the roll-train motors, the other a single-phase, alternating-current machine of 450 kw, at 3000 volts, for running the transformers at the 3-ton electric furnace. Another single-tandem engine of 800 hp runs two alternating-current generators of 250 kw and 335 kw, furnishing single-phase current for the other electric furnaces. A 150-hp machine runs the lighting dynamo.

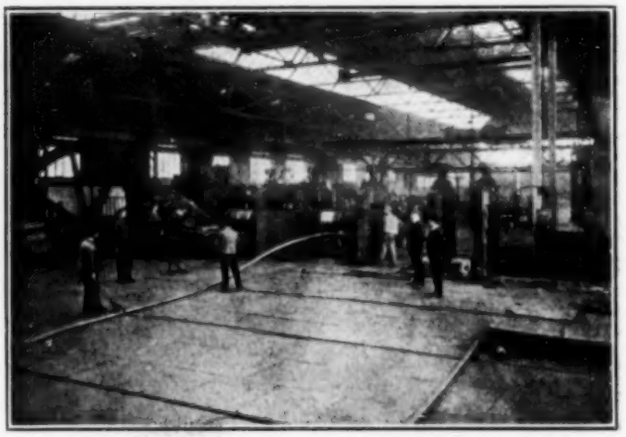


FIG. 7.—ROLLING-DOWN BILLET.

The casting floor is next to the furnace platform, the casting ladle being carried to the molds by an overhead traveling crane.

A 5-ton hammer (Fig. 5) serves to work down the 1-ton ingots, into which the steel is cast, to sizes suitable for the rolls. High-speed tool steel is cast into smaller ingots, which are worked down at a white heat, with frequent annealings, under a 1-ton hammer.

The old rolling train in an adjoining building is used principally for making saw-blanks (Fig. 6). Almost all the numerous saw works of Remscheid are supplied from this works. Its capacity is 6 tons of sheet steel in 24 hours, rolled to 0.6 mm up to 4 mm (0.025 in. to 0.16 in.). This train is run by a 350-hp steam engine.

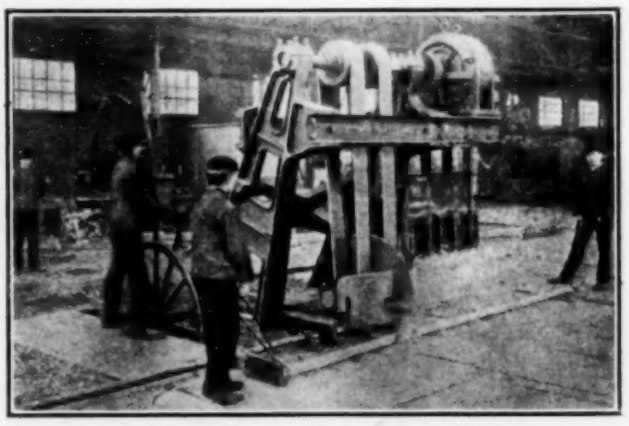


FIG. 8.—HOT SAW.

The new rolling mill is in a building 80 m (260 ft.) long by 22 m (70 ft.) wide, with a side-bay 8 m (26 ft.) wide. The billets from the steam hammer are reheated and passed through the breaking-down rolls (Fig. 7), then sawed hot to proper

lengths (Fig. 8) and finally rolled down to rod in the fine rolls (Fig. 9).

Both rolls are run by electric motors placed in the side-bay and run by the 450-volt direct current. The coarse rolls handle

FIG. 9.—FINE ROLLS.

60 tons in 12 hours, the fine rolls 10 tons to 30 tons, according to the section produced. The side hall also contains roll-turning equipment, and a polishing plant in which the billets are polished before being rolled (Fig. 10).

FIG. 10.—POLISHING THE STEEL BILLETS.

For smaller sections than can be rolled, the rolled bars are worked down as usual under trip-hammers (Fig. 11).

From every charge of high-speed tool steel a sample is taken

FIG. 11.—HAMMERING DOWN THE SMALL SECTIONS.

and tested (Fig. 12) in the lathe, where it must work satisfactorily at 25 m (80 ft.) per minute velocity, 25 mm (1 in.) depth of cut and 18 mm (0.75 in.) feed, on soft cast iron, giving a turning of a certain length before becoming dull.

One of the results of this great care is seen in the "Grand Prix" received by this firm at the recent exhibition in Liege. The firm's exhibit is shown in Fig. 13.

The electric steel has, on account of its purity and uniformity, shown itself highly suitable for permanent magnets. A considerable part of the production of the works is thus used in their own magnet shop. Figs. 14 and 15 show the forging and the machine rooms of the magnet plant. In another room the magnets are magnetized by passing through their two ends an alternating current. They are thus kept in the alternating

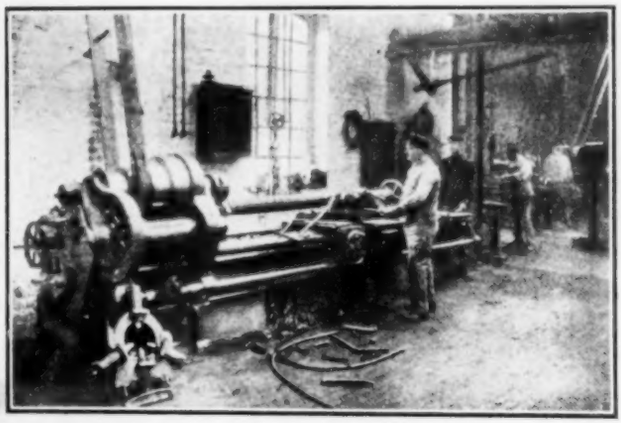


FIG. 12.—TESTING SHOP.

circuit until a maximum of residual magnetism remains in them.

Each magnet is then carefully tested by a specially constructed galvanometer, to plot with scientific accuracy the number of its magnetic lines of force and the strength of its magnetic field. The enthusiastic writer in *Deutsche Industrie* apostrophizes them somewhat thus:

"Cast in the sun-heat of the electric arc; pressed into shape by the electric rolls; given their magnetism by the electric current they are pure children of the electric force and all their

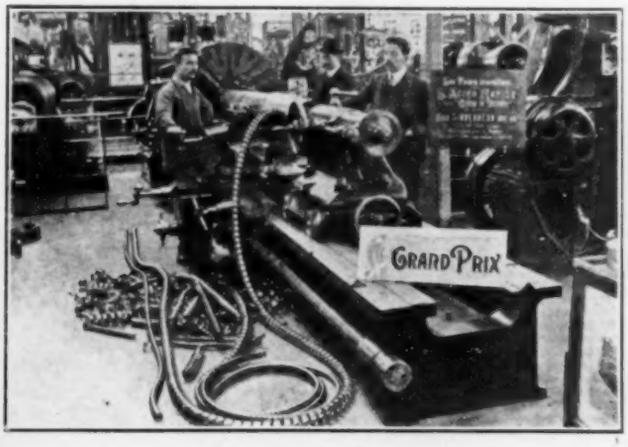


FIG. 13.—EXHIBIT AT LIEGE.

life possess electromagnetic strength. So do they through all the wide, wide world spread broad the fame of Goddess Electra!"

It is almost superfluous to say that such a works as we have just described possesses a fine chemical laboratory (Fig. 16), with microscopic and physical testing apparatus of the most modern kind (Fig. 17).

The Fine Electrical Steel Manufacture.

The first step is the manufacture of the steel in a tilting open-hearth furnace (Figs. 18 and 19). This is an ordinary basic-hearth Wellman furnace. The charges are pig iron, heavy

and light scrap, iron ore and roll scale. The charge is "over-oxidized" before being poured, in order to reduce phosphorus and sulphur to the lowest possible point.

"This strong over-oxidation was formerly impossible to practise, because no means were at hand to neutralize its effects. Only the invention of the electric process made possible this high preliminary purification of the molten metal, assuring thereby the highest possible purity of the steel."

The average composition of the metal from the open-hearth furnace, as given during the visit of inspection, was: Carbon, 0.05; Mn, 0.15; P, 0.01; S, 0.05. This analysis would show it not to be the "over-oxidized" metal spoken of by the writer in *Deutsche Industrie*, and also in the Héroult patents.

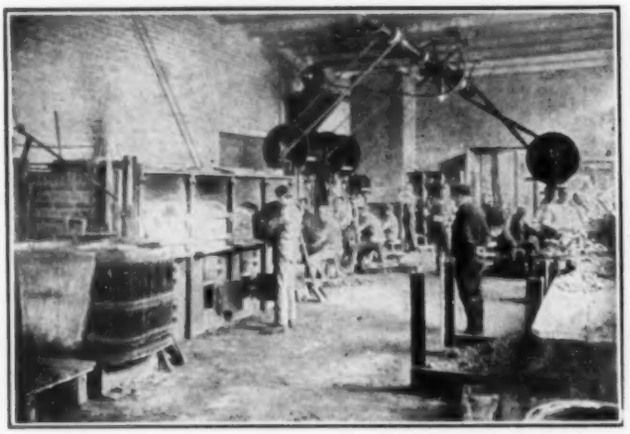


FIG. 14.—MAGNET FORGING PLANT.

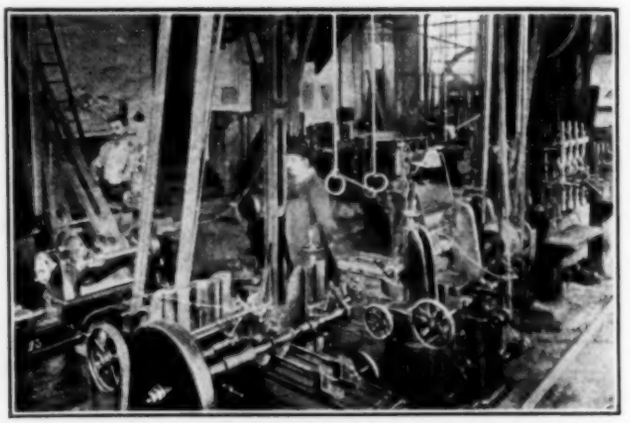


FIG. 15.—MAGNET MACHINING SHOP.

The electric furnace plant consists at present of a 1.8-ton Héroult furnace (Fig. 20) with acid hearth, and a 3-ton furnace with basic hearth, both of the usual Héroult construction. The molten steel is received from the open-hearth furnace in a 5-ton ladle, the ladle and contents weighed, then poured into the electric furnace, and the empty ladle with remaining slag weighed, so that the charge in the furnace is known to a kilogram.

The electrodes are 28 cm square, and fit snugly through the water-cooled sockets in the roof. They wear away 1½ cm to 2 cm (0.6 in. to 0.8 in.) per heat, or 2¼ kg (5 lb.) per ton of steel. The electrodes are automatically kept at 4.5 cm (1.8 in.) from the surface of the slag.

The electric current is supplied from the power station at 3000 volts, and is transformed to 100 volts or 110 volts by two transformers connected in parallel. The power-factor of the furnace varies between 0.90 and 0.93.

The power used by the 1.8-ton furnace is 250 kw, or 385 kw-hours per ton of fluid metal treated; the 3-ton furnace takes 350 kw or as low as 235 kw-hours per ton of steel treated. Of these 350 kw it requires 250 kw to keep the furnace up to a constant temperature, while the other 100 kw (Ca, 30 per cent) is used in melting the fluxes which are added and in raising the temperature of the bath.

While the temperature of the steel immediately under the electrodes rises very high, yet the average temperature of the bath as a whole is not greatly increased. Estimating the temperature of the metal put into the furnace as 1600° C., I should not place the temperature of the metal during casting at more than 1650°. The kw-hours consumed by the steel, allowing for radiation from the furnace, would not admit of more than this 50° C. increase.

The single-phase alternating current, at 25 periods, is charged to the furnace at 6 pfennigs (1.5 cents) per kw-hour; the cost of production (by steam engines) is 4½ to 5 pfennigs (1.12 to 1.25 cents). At this rate the power charge works out to 23.10 marks ($5.77) per ton of steel in the small acid-lined furnace, and 14.10 marks ($3.52) per ton of steel in the large basic-lined furnace.

The voltage drop from the main conductors to the electrode clamps is 1.8 volt, in the holders 1.8 volt, or together about 3.5 per cent of the power used in the furnace.

At the time of the writer's visit 2000 kg of open-hearth metal was put into the furnace at 8:40 a. m. Limestone and lumps of or were thrown in, and the current put on (Fig. 21). During the next 50 minutes the heating up of the metal took place, and i.s oxidation by the very fluid iron-lime slag.

At 9:30 some lime was thrown in, to stiffen the slag, the front door was opened, the furnace tipped forward a little, and with a hooked bar resting on the rod before the door the slag was scraped off into the pit (Fig. 22). Fig. 23 gives a nearer view.

FIG. 16.—CHEMICAL LABORATORY.

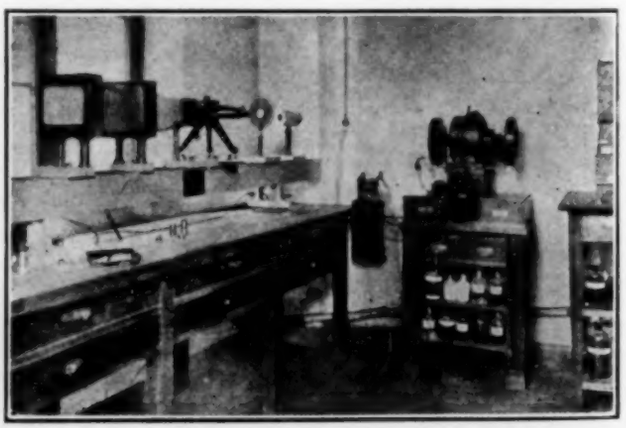


FIG. 17.—MICROPHOTOGRAPHIC LABORATORY.

The dark brown iron-lime slag being removed there were added lime and fluorspar, and as soon as these had formed a liquid slag some finely ground carbon was sprinkled over the surface. This carbon reduced strongly the iron oxide left in the slag. A sample of the slag was taken with a small cold iron rod. Before adding the carbon it was dark brown; as the carbon reduced it, it became lighter brown, until eventually it became almost white and fell to powder in the air at a little below red heat, say, at 300° C. The fineness of the carbon prevented it

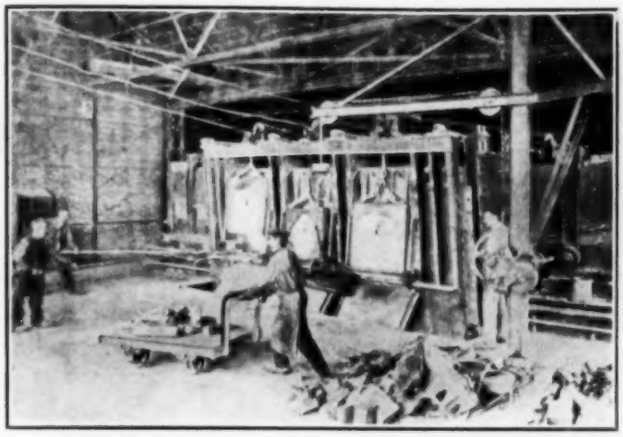


FIG. 18.—CHARGING THE OPEN-HEARTH FURNACE.

from sinking through the slag and carburizing the metal. The slag was then rendered non-oxidizing, and the dephosphorization of the bath was completed.

More lime and fluorspar were then added, and from time to time the following additions made: 16 kg of 50 per cent ferro-silicon, 6.75 kg of ferro-manganese, 18.5 kg of hard (carburized) ferro-chrome, 7 kg of ferro-manganese; later a large block of "carburite" (a briquette containing half carbon and half iron) was weighed and put into the furnace, being held under the surface by an iron bar so as to reach through the slag into the steel.

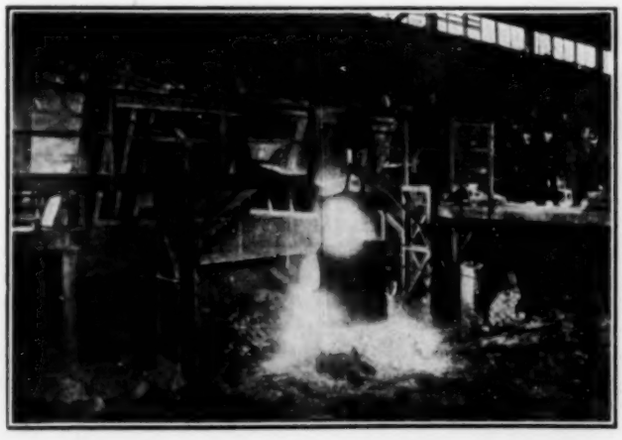


FIG. 19.—CASTING FROM OPEN-HEARTH FURNACE.

A test taken at 9:50 a. m. showed 0.51 per cent carbon, and at 10 a. m. 0.50 per cent. Since 0.65 per cent carbon was desired in the steel, the weighed block of carburite was again put in at 10:20 a. m., kept in about five minutes, taken out and weighed. Since 0.15 per cent of carbon was needed by the bath, equal to 3 kg of carbon, or 6 kg of "carburite," the block of carburite was taken out from time to time and weighed on a small platform scale. When 6 kg had been dissolved from it the block was thrown aside.

The slag was again tested, and proved nearly white, with a tinge of yellow due to chromium, and of the desired disintegrating quality in the air. Some acetylene could be detected when pieces of it were dropped into water, but not much.

The heat was tested by taking a round iron rod, 2 cm (0.8 in.) in diameter, bending the end to a hook, and holding it just inside the front door, near to the bath. As soon as it began to

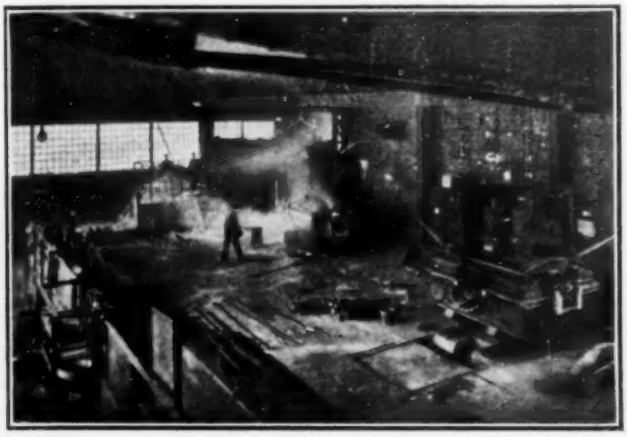


FIG. 20.—ELECTRIC FURNACE, WITH OPEN-HEARTH FURNACE IN BACKGROUND.

melt, and drops of liquid iron to fall from it, the workman plunged it rapidly about 0.6 m (2 ft.) into the metal, doing this twice in about one second of time, and then withdrew it. The hook was entirely melted off, and the bar melted to a sharp point.

I should judge that the bath was at this time some 50° above the usual open-hearth finishing temperature. A test ingot was poured, which set quiet like lead. A shovelful of fluorspar

FIG. 21.—CURRENT PUT ON THE ELECTRIC FURNACE.

was then thrown in, a red-hot ladle brought before the furnace, and the charge poured at 10:40 a. m.

The final slag is said to average 15 per cent silica, 50 per cent lime, and the rest calcium fluoride, calcium sulphide, calcium carbide, and traces of chromium protoxide and manganous oxide and an iron oxide lower than FeO—possibly Fe^3O.

The steel which was aimed at in this heat was: Carbon, 0.65; Mn, 0.6; Si, 0.4; Cr, 0.5 = 0.6; P, less than 0.01; S, less than 0.01 per cent.

The steel was cast (Fig. 25) into six different sized ingots. It poured and stood absolutely quiet in the molds, like melted lead. To avoid shrinkage a little steel was poured in afterward to fill the shrinkage cavity. The stopper worked accurately, without any splashing or foaming around the nozzle. In all respects it acted like best dead-melted crucible steel.

The banks of the furnace were then made up with burnt dolomite, and at 11:10 a. m. another charge put into the furnace. The actual treatment took two hours; 10 charges are usually worked per day.

As to the reactions in the process, phosphorous and other oxidizable elements are completely eliminated by the first slag; copper and arsenic are not, and should, therefore, not be in the molten metal charged in any harmful quantity. Sulphur is

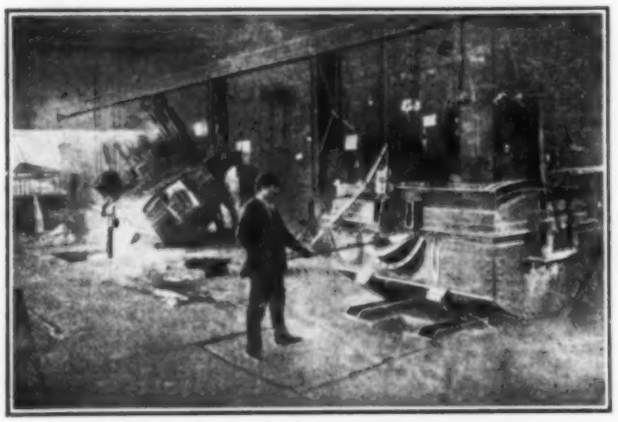


FIG. 22.—REMOVAL OF SLAG. FURNACE IN BACKGROUND BEING TAPPED.

eliminated by the action of calcium carbide formed in the second slag:

$$CaC^2 + FeS = CaS + FeC^2.$$

In this second stage, silicon, manganese, chromium, nickel, vanadium, molybdenum, boron or tungsten are added to the steel with quantitative accuracy, scarcely a trace of any of these additions passing into the slag and the steel having the exact calculated composition.

Comparing the electric process as here developed with the

FIG. 23.—ELECTRIC STEEL FURNACE.

crucible process here displaced, the management, after five years' experience, affirms with the greatest positiveness that the electric steel is more nearly of the desired composition, more uniform in composition, can be made from far cheaper raw materials, costs far less for the smelting operation, far less for labor, the labor required is much easier and safer, the output per given sized plant is greater, the steel is more free from blow-holes, develops less edge-cracks or surface faults, and for a given ductility will carry more carbon and therefore show higher strength.

Americans, wake up!

Zinc Ore Dressing in Colorado

By H. C. Parmelee.

Marion Mines and Mills Company.

An interesting example of the development of economical ore dressing under conditions which, at first sight, might be considered unfavorable is to be found in the operations of the Marion Mines & Mills Company. Given an ample supply of ore, good milling facilities and adequate water power, the company has demonstrated that it will be able to operate successfully despite a 26-mile wagon haul to put concentrates on board cars.

The company's property is located at an altitude of 9600 ft. in the Greenhorn range, at Fairview, Custer County, Col., about 45 miles southwest of Pueblo. The mining property comprises 12 claims, giving 4500 ft. on the main vein and protecting the sites of reservoir, pipeline, mill and town. The mineralized fissure occurs in granite and is composed of schist and altered granite with sulphides of zinc, lead and copper. The ore is found in zones from 300 to 400 ft. in length and of an average width of 15 ft. Where the main tunnel cuts the vein the ore is 25 ft. thick and assays 22 per cent zinc. The zinc content varies from 12 to 22 per cent.

FIG. 24.—TESTING THE TEMPERATURE.

Power.

The development of cheap power is the key to the situation, and water power has been provided for all mining and milling operations. Located at an altitude of 10,780 ft., or about 1100 ft. above the mine and mill, and distant about 1¼ miles therefrom, is the reservoir and dam. The area of the former is 41.5 acres and its capacity is 21,800,000 cu. ft. The surrounding watershed is heavily wooded and snow and rainfall are well conserved. The water thus provided is sufficient for operating the mill 24 hours per day throughout the year.

The dam is of heavy timber and rock construction with its foundations on bedrock. When completed according to present plans, it will be 360 ft. long between massive natural rock abutments, 50 ft. wide at bedrock and 16 ft. wide at the top, which is 52 ft. above bedrock, or 45 ft. above the earth level at the center of the dam.

The pipe line from reservoir to mill is 6300 ft. long. Beginning at the dam, 10-in. spiral riveted pipe with Root joints extends for 5220 ft., increasing gradually in strength from No. 16 to No. 8 steel. The next 400 ft. of pipe are of 8-in. spiral riveted No. 8 steel and the last 680 ft. to the mill are of 8-in. No. 8 lap-welded steel. The pressure gage at the water wheels in the mill shows 1070 ft. of water in the column and a pressure of 465 lb. per square inch. Engineers' estimates of the power developed by this system average about 300 hp. The power now consumed in milling operations is but 65 hp,

and the proposed addition to the mill, mentioned later, will require but 15 hp additional.

The water wheels used are Hug and Pelton high-pressure wheels. For mining operations one 24-in. Hug wheel drives the air compressor and one 15-in. Hug is direct-connected to the hoist. Air is supplied for ventilation by a fan driven by a 12-in. Pelton wheel, and electric lighting for mine, mill and camp is provided by a dynamo driven by a 12-in. Hug wheel. The mill is operated by two wheels, the crusher, rolls, elevators and tube mill being driven by one 24-in. Pelton and the 11 concentrating tables by one 12-in. Hug. The 24-in. Pelton just referred to is one of two on the same shaft so that either may be used for present operations, or both in case increased power is required. The new addition to the mill will have one 18-in. wheel for the tables and one 12-in. wheel for the pump elevating middling. The nozzles used in connection with the wheels mentioned vary in diameter from 3/16 in. to 5/8 in., and the valve gates are only partly opened. Fire protection is provided at several points in the mill, the water for this system being taken from the main pipe line through a reducing valve.

One of the advantageous features of this water power system is the steady transmission of power in the mill. After the water wheels have been adjusted to their proper speed there is no variation in their running, and the result is a remarkably steady operation of every machine.

Milling.

The Marion ore lends itself quite readily to a system of wet dressing, which has been adopted after testing the efficiency of several other methods. The mineral particles in the ore are small and quite finely disseminated throughout the gangue, necessitating fine grinding for their liberation from the gangue and for the separation of the different minerals from each other.

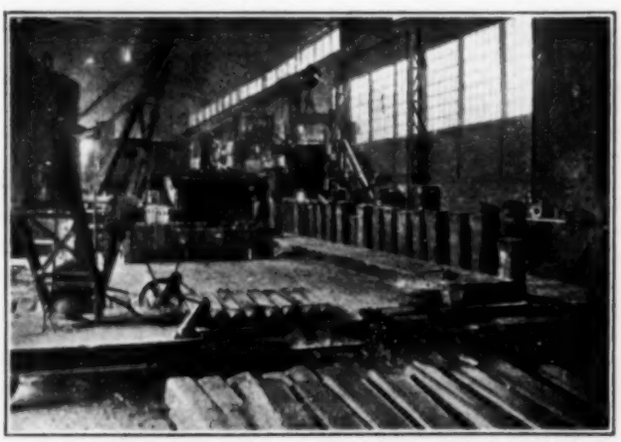


FIG. 25.—CASTING THE STEEL.

After considerable experimenting an adequate system of ore dressing has been devised which, while it may be subject to minor changes and improvements, has been adopted essentially as given below. One of the problems encountered in treating this ore, viz., the necessity for fine grinding to liberate the mineral particles, has been met with an innovation in the use of the tube mill for grinding a large part of the table feed to 40 mesh. The tube mill has been a successful adjunct to metallurgy where very fine grinding or sliming is a preliminary operation, and it has also been introduced for the regrinding of middlings prior to retreatment on concentrating tables, but its use on the first break of the ore prior to any classification or dressing is believed to be novel. Its successful application in this instance may widen the possibility of its use in ore dressing.

The flow of the ore through the mill and the details of the operation of some of the machines are given below. The mill is located at the mouth of the tunnel through which the ore is trammed a distance of about 200 ft. Coarse crushing is done with a No. 4 Samson 8 x 16 crusher, reducing the ore to 1-in. size. This product passes to 250-ton bins whence it is delivered by an automatic feeder to a set of 14 x 27 McFarlane rolls, discharging to a 14-in. B. and B. elevator which raises the pulp to the trommel screen line. The trommel screens vary from 5-mesh to 40-mesh, the undersize from the latter being a finished product, and all intermediate sizes being returned for regrinding. Trommel No. 1 has a 5-mesh screen and discharges its oversize to a second set of McFarlane rolls and its undersize to trommel No. 2. This is fitted with 8-mesh screen; the oversize is returned to a third set of rolls and the undersize to trommel No. 3. This last trommel has 40-mesh screen, the undersize being ready for table treatment and the oversize passing to the tube mill for further reduction. The tube mill is Denver Engineering Works type 10 ft. x 4 ft., revolving at the rate of 28 to 30 r.p.m. All rolls discharge to the same elevator which supplies the trommels. The tube mill product, however, is not screened again, but is combined with the undersize of the 40-mesh trommel screen and delivered to a 6-ft. Callow thickening cone preparatory to classification.

The pulp is classified for table treatment by a Richards 4-in. six-compartment pulsator classifier making 320 pulsations per minute. The first two compartments discharge to two 4-ft. Callow thickening cones (which also receive the overflow from the first Callow cone), where the fine grades are again thickened before going to the tables. The third, fourth, fifth and sixth compartments are discharged directly to the tables. Card tables are used throughout the mill and give excellent satisfaction. The overflow from the second and third Callow cones passes to two more cones which thicken the feed for one table treating the finest grade.

All concentrates are discharged automatically to filter bins beneath the table floor, where they are dewatered for shipment. These bins are of the usual double floor and wall construction with cocoa matting in the floor and burlap in the walls.

Data.

The table products are (1) lead concentrate, (2) zinc concentrate, (3) zinc middling, (4) tailing and (5) slime. The first is very small in quantity, but carries the major percentage of the gold and silver in the ore. The zinc concentrate averages a little better than 40 per cent zinc. The middling assays about 15 per cent zinc, and it is for the retreatment of this product that a new addition will be made to the mill. Experiment has shown that the middling can be concentrated on tables without futher crushing, and it has been found advisable first to make as high grade and clean zinc concentrate as possible and then retreat the comparatively rich middling on separate tables. Throughout the mill the idea has prevailed that each machine should be allowed to make the best possible finished product and that unfinished products should not be returned to the same machine but rather to another which can rectify the errors of the first. The slime waste offers a problem which has not yet been solved. This material consists mainly of fine scales of mica which concentrate in the overflow of the Callow tanks. It carries about 15 per cent zinc and is at present collected in settling boxes.

Prior to the introduction of the tube mill the rolls used for fine crushing were unable to reduce the ore fine enough to liberate the mineral particles, and large quantities of screen oversize accumulated so that occasionally it was necessary to shut off the mill feed until the oversize could be reduced by repeatedly passing it through the rolls.

The performance of the tube mill has been satisfactory in that it handles 8-mesh material and discharges a granular product without an excess of slime. The mill has a silex lining and carries a load of pebbles equal to about two-thirds the load used for very fine grinding. The condition of the product is regulated from day to day largely by the quantity of water supplied. Capacity tests indicate the possibility of handling

75 tons per 24 hours in this tube, and it is now crushing about 40 per cent of the mill feed, 60 per cent being handled by the rolls. The following screen analysis shows the work of the mill on an 8-mesh feed.

	Per cent.
On 30 mesh	1.28
40 "	4.49
50 "	12.18
66 "	17.30
86 "	17.95
116 "	16.67
172 "	14.10
200 "	4.49
Through 200 "	11.54

This shows about 65 per cent of the material between 40 mesh and 116 mesh, with the production of but 11 per cent slime. Various other tests indicate that about 10 per cent slime can be maintained in steady operation.

The Richards pulsator classifier is doing effective work on this ore and is superior to the device employed prior to its introduction. The following screen analyses show its work:

First Compartment. Slime, 18.6 per cent Zn.

	Per cent.
On 66 mesh	2.92
97 "	12.13
200 "	48.54
Through 200 "	36.41

Second Compartment. Fine, 24.4 per cent Zn.

	Per cent.
On 50 mesh	2.3
97 "	34.1
200 "	45.4
Through 200 "	18.2

Third Compartment. Medium Fine, 15 per cent Zn.

	Per cent.
On 50 mesh	2.13
86 "	44.49
116 "	22.24
200 "	22.24
Through 200 "	8.89

Fourth Compartment. Medium Fine, 13.4 per cent Zn.

	Per cent.
On 40 mesh	2.85
66 "	25.72
86 "	20.00
116 "	22.85
172 "	11.42
Through 172 "	17.16

Fifth Compartment. Medium Coarse, 17.1 per cent Zn.

	Per cent.
On 40 mesh	2.09
58 "	25.00
86 "	31.25
116 "	22.91
172 "	6.25
Through 172 "	6.25

Sixth Compartment. Coarse, 13.4 per cent Zn.

	Per cent.
On 40 mesh	3.33
50 "	33.33
74 "	30.00
116 "	20.00
Through 116 "	13.33

The cost of mining and milling is given by the management at about $1 per ton, divided about equally between the two operations. Transportation costs $5 per ton for the wagon haul and $1 or $2 per ton for freight to the Pueblo or Kansas markets respectively. This makes the total cost of mining, milling and transportation $7 or $8 per ton according to the market supplied. As transportation is the largest item of the total cost, special attention is given in the ore dressing to the quality of the concentrate produced, rather than to the quantity, and refinements will be introduced whenever possible to reduce losses in the by-products.

Acknowledgment is made of the courtesy of Manager Henry J. Gray and Consulting Metallurgist J. M. McClave, who have supplied the data herewith given.

The Influence of Impurities on the Properties of Copper.

By F. Johnson, M.Sc.

So profound are the effects of traces of impurities upon the physical and mechanical properties of copper and so mysterious the diversity of those effects, that the writer deems it unnecessary to apologize for publishing the following notes, based on the work of others and amplified by his own observations. He does so, therefore, in the hope that they may contribute toward the stimulation of the desire of metallurgists to have supplied the present lack of knowledge in this important subject.

Arsenic hardens, toughens, increases tensile strength and ductility when present up to at least 1.5 per cent. It does not impair the forging properties when added to pure copper, even beyond 0.5 per cent, except that the forging temperature may not be quite so high as that for pure copper; it invariably *improves* the forging properties where added to impure copper. It is now largely specified for in material—such as locomotive and boiler tubes, fireboxes and firebox stays, steam pipes, etc.—which is required to withstand high temperatures, since mechanically hardened arsenical copper is not softened at so low an annealing temperature as pure electrolytic copper, which has undergone identical treatment. The strength and toughness, too, of arsenical copper is greater at high temperatures than are those of pure, unadulterated copper or those of most brands of impure copper without arsenic. Arsenic enters into solid solution with the copper which, in the cast state, is not perfectly homogeneous, but attains in the forged and annealed state, crystalline uniformity of composition as a result of diffusion and recrystallization. Copper containing arsenic and oxygen is stronger, "ceteris paribus" than copper containing arsenic and no oxygen (deoxidized).

Micrograph No. 1 shows the structure of cast arsenical copper containing 0.5 per cent arsenic. "Cores" of arsenically contaminated copper merge gradually into, and are completely involved by, a network of a solid solution of copper richer in arsenic, paler and stronger than the "cores" of primary solidification.

Micrograph No. 2 shows the structure of a piece of the same copper which has been forged hot and annealed.

Arsenic lowers the electrical conductivity of copper in a most pronounced and startling way. Hiorns & Lamb (J. S. C. I., May, 1906) offer a theory that arsenic improves copper by reason of its deoxidizing effect on cuprous oxide. This is erroneous, as a furnace-charge will contain an excessive quantity of oxygen side by side with arsenic. The oxygen may be removed by poling, leaving the proportion of arsenic unaltered.

Arsenic reduces the solvent power of molten copper for reducing-gases and so renders it less susceptible to going over the pitch by excessive "poling."

Mr. Tomlinson (see discussion page 47, "The Treatment of Copper for Steam Pipes," J. T. Milton, Inst. Marine Engrs, 1908-1909) has supplied the following data regarding the superiority of tough arsenical copper over pure copper:

(1) Samples of each, which had been hardened by rolling, were kept at a temperature approaching 400° Fahr. for three or four weeks. This treatment did not affect the arsenical copper, as shown by tensile tests, but the pure copper samples were practically annealed.

(2) Similar samples were heated to 1600° Fahr. (870° C.) (approaching bright red) for four hours. The sample of arsenical copper lost only 6 per cent of its tensile strength, while the sample of pure copper lost 44 per cent.

The percentage of arsenic in the arsenical samples was 0.36

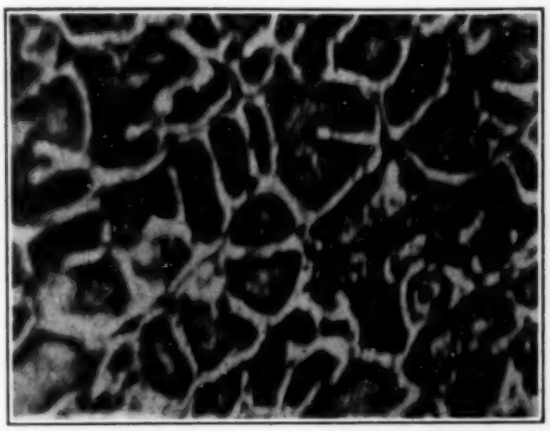


FIG. 1.—COPPER CONTAINING 0.5 PER CENT ARSENIC AS CAST.

per cent, so that copper containing arsenic does not become annealed at the temperature of steam at the highest working pressures, whereas pure copper does. Also, prolonged heating does not so seriously lower its strength as it does that of pure copper.

Arsenic undoubtedly improves the hot-working properties of copper vitiated by traces of bismuth.

Lead.—This element is to be found in all ordinary commercial copper, but is not desirable in any proportion over 0.10

FIG. 2.—SAME AS FIG. 1 AFTER FORGING HOT.

per cent, and the lower the proportion under 0.10 per cent the better.

The lead reduces the strength, ductility and toughness of copper even in the presence of arsenic, the reason being that copper has very little solvent action for lead, the latter merely honeycombing the structure with more or less uniformly distributed prills of lead or prills of lead containing traces of copper.

Comparisons of tests carried out on samples of copper sheet and tube by Mr. J. M. Allen and described before the N. E. C. I. of Engineers and Shipbuilders, January, 1909, go to prove this statement.

CHEMICAL ANALYSES.

	Sheet per cent.	Tube per cent.
Copper	99.040	99.360
Lead	.407	.160
Arsenic	.410	.304
Oxygen	.042	.050
Iron	.035	.041
Nickel	.050	.047

	Tensile Strength. Tons Strength.	Elongation. % on 3".	Toughness. No. of times bent to and fro.
Sheet, untreated	14.50	42.0	36
Tube, "	15.37	41.7	61.5
Sheet, heated 6 times to bright red and quenched	14.22	40.5	49.5
Tube treated in same way	15.0	45.0	74.5

Lead existing free in copper, and having so low a melting point, will render the copper more susceptible to *"burning"* during any reheating or annealing process, and also affect its malleability at a red heat.

The addition of lead to copper has the effect of lowering the affinity of copper for reducing-gases.

Nickel alloys with copper in all proportions, forming a complete series of homogeneous solid solutions. Traces of nickel in copper are beneficial, imparting strength, toughness

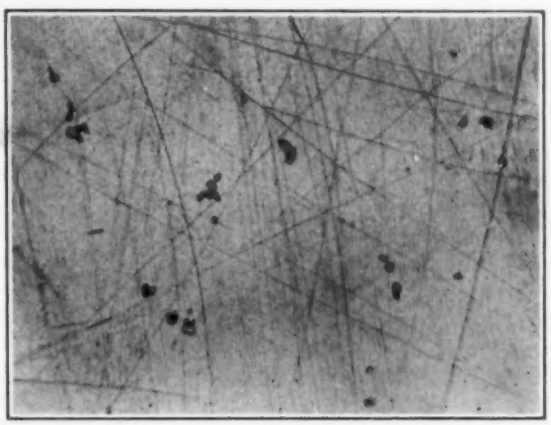


FIG. 3.—COPPER CONTAINING 1 PER CENT ARSENIC. VERY SLOWLY COOLED.

and increased resistance to deformation at high temperatures. Nickel must be kept low where arsenic is present, 0.10 per cent being quite sufficient to harden arsenical copper which has to withstand severe working. The stronger affinity which nickel has for arsenic lends color to the belief that an arsenide of nickel is formed which has a much lower degree of solubility in copper than either nickel or arsenic alone, and seriously hardens the metal. Below 0.05 per cent, even in the presence of arsenic, its effect upon the physical properties, excepting electrical conductivity, may be considered almost nugatory. Copper containing traces of nickel is no less susceptible of dissolving reducing-gases than pure copper. Webb's experiments on locomotive tubes showed that copper tubes containing 3 per cent nickel were first in order of merit, while Johnson found that copper stays containing 3 per cent nickel and 1.6 per cent iron showed admirable results when tested at high temperatures.

Micrograph No. 3 shows the structure of pure copper containing 1 per cent arsenic. The alloy had been very slowly cooled, the endeavor being made to render the *process of solidification* as protracted as possible. The usual "core" structure of cast arsenic-copper alloys is much more subdued, and, in fact, is barely discernible. Small isolated areas of Cu_3As are discernible. Micrograph No. 4 shows the structure of an alloy treated exactly similarly to the above, but containing 1 per cent nickel in addition to 1 per cent arsenic. No new

compound or constituent appears, in fact, even the Cu_3As areas are fewer, but the "cores" are very much more pronounced, indicating greater crystalline hardness.

Bismuth has by far the most deleterious action of all the impurities found in copper. One hundredth per cent renders commercial copper noticeably less malleable at a red heat, but (and here the writer must reassert the value of arsenic in suppressing the ill-effects of bismuth), if arsenic is present, as it should be in all wrought copper not required for electrical purposes, the allowable percentage of bismuth may be considerably higher. By regulating the proportions of arsenic and oxygen in pure copper the writer has obtained with the addition of 0.1 per cent bismuth very respectable tensile results.

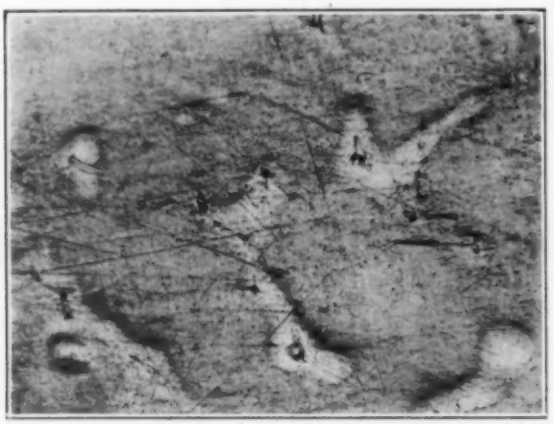


FIG. 4.—COPPER CONTAINING 1 PER CENT ARSENIC AND 1 PER CENT NICKEL. VERY SLOWLY COOLED.

The metal forges well at a red heat (not bright red), but is inferior in this respect to pure copper or to good tough arsenical copper. The writer finds, however, that the forging properties of copper, originally inferior in this respect in the cast state, are considerably improved by hot-forging. We must here assume that the combined effects of distortion of crystals and their simultaneous recrystallization which the process of hot-forging embraces must also create, in addition to a refinement of structure, greater inter-crystalline tenacity, and, perhaps, the literal incorporation, as it were, into the architecture of each crystal of those external envelopes of less pure copper, which, in the cast state, *involved* each crystal and lowered the malleability of the metal as a whole. (This refers to copper containing any impurities which are commonly associated with it.)

Continuing this reasoning, it is safe to assume that the impure envelopes would have a lower freezing point than the purer centers, and that their malleability would represent the malleability of the copper. But intermolecular diffusion and consequent rectification of crystalline composition which reheating and hot-forging have produced render the metals less susceptible to the incipient disintegration, which develops—in the cast and unstable state—when it receives the first pressure of the hammer or of the rolls.

Bismuth does not enter into solid solution with copper, but finds its way, in the metallic form, toward the boundaries of the crystals and there solidifies, long subsequent to the solidification of the copper crystals (See cooling curves of Cu-Bi Alloys, Plate 32, 2d report, Alloys Research Committee, Inst. Mech. Engrs., 1893.) Hence the strength of the copper is practically represented by the strength of this brittle membranous material. But if oxygen be present, the segregation of bismuth is, if not prevented, markedly retarded, and it is the belief of the writer that cuprous oxide assumes a physical relationship toward bismuth, and, when rejected to the boundaries by the solidifying crystals, it shepherds it into areas of eutectic form, where minute granules of cuprous oxide occur uniformly in a matrix of solid copper constituting a solid eutectic necessarily stronger and less deprivatory of inter-crystalline adhesion than brittle plates and films of a metal of low freezing point, such as is shown in micrograph No. 5. The bismuth is trapped in the eutectic in the form probably of an oxide of bismuth.

Returning once more to the theory of the benefits of hot-forging, we may argue that such a constituent of copper as the solid eutectic just described will be more harmful when existing isolated in large angular areas as in the *cast* material than in the more uniformly disseminated form consequent on forging, the dangerous coalescence having been broken up to the production of greater homogeneity by distribution.

Summing up the effects of hot-forging:

(1) The structure is refined and strength increased thereby.

(2) Copper-cuprous-oxide eutectic areas are broken up and uniformly distributed.

(3) Crystalline composition is rectified by diffusion of impurities from the envelopes of brittle material into the softer primary crystals or "cores" (as in the case of arsenic).

(4) Porosity, due to occluded gases, is greatly removed.

The writer feels bound to think that all theories as to the formation of bismuthide or bismuthate of copper are untenable. If bismuth existed free as metallic bismuth in copper containing oxygen, then there should be an arrest in the cooling curve, after the solidification of the copper-cuprous-oxide eutectic. If such be the case, and if that arrest were capable of detection, then the beneficial effect of oxygen can only be physical in coercing what would otherwise be separating films between the crystals into less harmful prills or globules.

It may be that cuprous oxide has a solvent action for bismuth which copper does not possess and that bismuth, therefore, is less harmful in the form of a solid solution in cuprous oxide than as free metallic bismuth. Or, finally, the cuprous

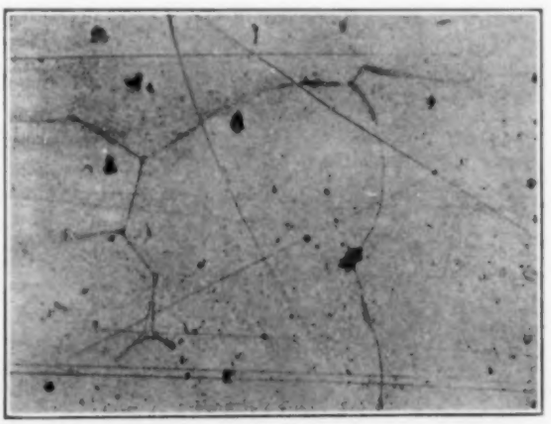


FIG. 5.—COPPER CONTAINING 0.5 PER CENT BISMUTH.

oxide granules of the eutectic may be partly replaced by bismuth oxide granules, bismuth taking up oxygen at the expense of cuprous oxide, thus throwing some copper out of combination. This is the view most favored by the writer.

Cobalt—Little is known about the influence of this metal. Personal experiments confirm the writer's belief that it toughens and strengthens copper when present up to at least 1 per cent without impairing its hot-working properties. Probably it acts very similarly to nickel, conferring greater durability at high temperatures and raising the annealing temperature, while toughening, hardening and strengthening the copper in the cold. Cobalt, in the low percentages in which it is found in copper, is, if anything, beneficial, and moreover, it does not disagree with arsenic to so great an extent as nickel does.

Antimony hardens and strengthens copper and is not detrimental when present up to 0.5 per cent if other impurities are absent and a small percentage of oxygen is present.

Johnson (Birmingham Metallurgical Society, 1906) records that copper containing 0.5 per cent antimony had, after hot and cold working and annealing, a tensile strength of 15.6 tons per square inch, and an elongation of 45 per cent (on 2").

Hiorns & Lamb (J.S.C.I., May, 1909) state that antimony does not lower the electrical conductivity of copper so profoundly as arsenic, that it has not such a hardening effect as measured by the scleroscope, that it is not so efficacious in decreasing the porosity of cast copper, and that it impairs the cold malleability to a greater extent than arsenic. They failed to draw into wire copper containing more than 0.6 per cent

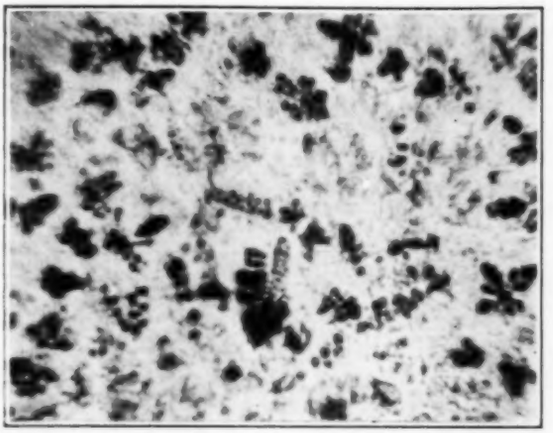


FIG. 6.—COPPER CONTAINING 16 PER CENT CUPROUS OXIDE.

antimony. The writer finds that by adding oxygen it is possible to draw into wire copper containing 3 per cent antimony.

Sir H. Vivian stated that 1/1000 part of antimony (0.10 per cent) will convert best selected copper into the worst conceivable. It must be remembered, however, that it is when the copper is used for alloying that the effect of antimony is so marked. In wrought copper, antimony is not so detrimental.

Tellurium.—Very little is known of the effect of tellurium in commercial copper. A writer in the Journal of the Society of Chemical Industry (1907, p. 695) remarks that 0.05 per cent tellurium is discernible in copper under the microscope. "Wallaroo" copper and some Japanese brands are said to contain traces of tellurium. Cloud (Inst. M. & M. Journal, 1906-7, p. 67) gives an analysis of "Wallaroo" copper showing 0.003 per cent tellurium. Prof. Huntington thinks that the minute traces of tellurium, if alone, are not so harmful by themselves as when they occur together with similar traces of bismuth. He thinks that the single effect of each in mere traces may be insignificant, but that their occurrence together signifies the formation of a telluride of bismuth whose ill effects are very much more pronounced. Prof. Roberts-Austen (2d Report) found that copper containing 0.2 per cent tellurium had a tensile strength of 10 tons per square inch, and an elongation of 13.6 per cent, compared with pure copper, which, having undergone the same treatment, had a tensile strength of 13.2 tons per square inch, and an elongation of 27 per cent —a loss of 24 per cent tensile strength and 50 per cent elongation.

Iron occurs in refined copper in the merest traces, which are quite harmless. The average of eighteen analyses of firebox plates given by Mr. Dean in the second report to the Alloys Research Committee shows only 0.006 per cent iron. When all the sulphur has gone from a charge of copper, a sample taken from the furnace shows an unblistered surface, and is said to be "set-copper." At this point all the iron has been eliminated save that trace which is destined to remain in the copper to the bitter end.

Iron acts as a deoxidizer when added to copper. Copper containing only 1 per cent iron is rendered feebly magnetic, will forge well at a red heat, is quite malleable, tough and strong, even in the presence of arsenic. It lacks the fluidity of pure copper when poured at the same temperature.

Copper deoxidized by iron exhibits a closer surface when cast in an open mold; the characteristic waves as seen on the surface of a "tough-pitch" bar are replaced by waves more minute, more numerous and more regularly arranged. Even 0.05 per cent iron causes a central longitudinal furrow in a cast bar.

Tin hardens copper more than any other element. It occurs very rarely in commercial copper, being readily eliminated during the process of smelting. Low percentages of tin improve the tensile strength, ductility and resistance to corrosion, and maintain these improvements at high temperatures, but the natural softness of copper and its red color are both materially removed, its malleability also decreasing.

Tin rarely occurs in smelted and refined copper in quantities over 0.10 per cent.

Locomotive tubes containing 1 per cent tin, and made from castings deoxidized with phosphorus, came seventh in order of merit in a practical trial made on ten makes of tube in a L. & N. W. Ry. engine, 1898-1901 (Webb. *Proc.* I. C. E., CLV, 1903-4).

Silver is rarely present in sufficiently high percentage to impair either the hot or cold working properties of copper. It is more injurious on the hot-working properties of copper when arsenic is not present. Five one-hundredths per cent silver in pure copper does not affect its malleability at a red heat, while 0.2 per cent can exist in copper containing 0.3 per cent arsenic with quite beneficial effects on the tensile strength and no diminution of its malleability.

Sulphur.—Arnold* has shown that under the artificial conditions of slow-cooling and entire exclusion of oxygen

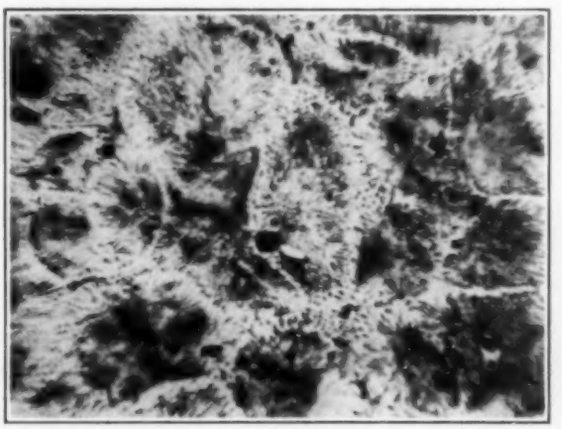


FIG. 7.—COPPER CONTAINING 3.2 PER CENT CUPROUS OXIDE AND CONSISTING WHOLLY OF THE COPPER-CUPROUS OXIDE EUTECTIC.

0.2 per cent sulphur in copper appears as attenuated sulphide walls, and as green globules in the interior of the crystals, or sometimes near the edges in groups of elongated leaves. Hampe (Zeitschrift für Berg-Hütten und Salinen-Wesen im Preussischen Staate, 1873, Vol. XXI, p. 274) found analytically that cuprous oxide, cuprous sulphide and sulphur dioxide could exist together in "tough-pitch" copper, and Heyn (Metallurgie, Vol. 3, p. 73, 1906) showed that cuprous sulphide, like the oxide, was of a bluish color until etched in hydrofluoric acid, when the oxide was stained black and the sulphide retained its blue color. Sulphur rarely occurs in more than harmless traces in commercial copper, yet it may occur to the extent of 0.03 per cent (SO_2) in electrolytic copper having a conductivity of 101.2 per cent. The presence of this element may possibly account for the unsatisfactory nature of copper used in jewelers' alloys. It derives its origin from two sources, viz., (1) the incomplete removal of sulphur from

*Engineering, 1896.

the sulphate liquor in which the copper cathodes were deposited, and (2) the sulphurous gases from the fuel of the reverberatory refining furnace being partially dissolved by the bath of molten metal, as they pass over it on their way to the flue. In the first case the sulphate would probably be reduced to sulphide by the reducing action of "poling," and in the second case, sulphur dioxide would be absorbed and retained as such. Suffice it to say that cuprous sulphide is a highly dangerous, brittle constituent, and its presence in any alloy would be very detrimental.

Lewis (Engineering, Dec. 4th, 1903) states that manganese and aluminium when present in quantity of 0.5 per cent are capable of neutralizing the effect of 0.1 per cent sulphur. His explanation is that manganese by dissolving in the copper crystals gives them the property—which pure copper does not possess—of holding copper sulphide in solution. This is probably erroneous, the effect possibly being analogous to that of manganese in steel, MnS being formed owing to sulphur having a greater affinity for manganese.

Oxygen.—All furnace-refined copper contains some oxygen. The amount will depend upon the quantity and nature of impurities present, and upon the skill of the refiner in producing copper at the highest possible stage of "tough-pitch." That is to say, it is possible to produce ingots, wire-bars, etc., which shall roll or forge, and withstand the severest deformation in cold-working or cold mechanical tests, but, it is still possible, by reducing or increasing the oxygen content, as the case may be, to obtain that delicate balance of oxygen on the one side and impurities (including dissolved gases) on the other, where strength, ductility, malleability and toughness reach their relative maximum values.

It may at once be said that oxygen is indisputably essential in all commercial impure wrought copper which has to withstand repetitions of small stresses, exposure to atmosphere, influence of corrosive agents, and varying thermal conditions. Steam pipes made of pure *electro-deposited* copper have been known to disintegrate after two or three years' exposure to the atmosphere, and even after two or three months, if under steam-pressure. The reason is their susceptibility to annealing or softening at such low temperatures as that of ordinary steam-pressure. If pure electrolytic copper be melted down in a refining furnace and brought up to pitch, i.e. brought to the stage where it contains about 0.05 per cent oxygen, and cast into billets or bars it will, after going through the various stages of manufacture, give in its finished state excellent results, both as regards accommodating itself to stresses and withstanding high temperatures. With the addition of arsenic these properties are still further enhanced.

Electro-deposited copper may be said to be structureless, and its ductility when annealed is possibly not to be excelled by any other form of pure copper; Le Chatelier has shown that at 400°C pure copper is singularly liable to disruption. Its very ductility is a source of danger, for even the deformation produced by successive expansions and contractions will destroy it. What has already been written regarding "slip-bands" may apply here, for it is readily conceivable that the "slip-bands" induced by stresses will be the more easily propagated and developed through a mass of metal where there are no arresting planes such as occur in a more definitely crystalline metal of homogeneous structure. (See micrograph No. 9 of "tough-pitch" electrolytic copper.)

So that, possibly, the influence of oxygen is indirect, in that it is only necessary to ensure the production of sound castings possessing a crystalline as distinct from an amorphous structure, and a sound as distinct from the porous condition which cast copper assumes when the oxygen has been removed and replaced by reducing gases such as hydrogen and carbon monoxide, soluble in the copper while molten, but expelled during solidification when the copper has been poured and allowed to set where atmospheric air has free access to it.

Concentration of stresses on one spot, accompanied by local softening (due to the fact that electro-deposited copper anneals at the low temperature of 200°C) may account for the inevitable failure of such material. Also, it may be that impure copper having its annealing temperature so much higher never undergoes this local softening and all stresses are taken up uniformly throughout the length of a steam pipe (The Treatment of Copper for Steam Pipes," J. T. Milton, Inst. Marine Engrs., 1908-9, Vol. XX), but this theory of the failure of electro-deposited copper fails to explain why such material fails after being in use at only normal temperatures.

M. Le Chatelier has shown that electrolytic copper, worked and annealed, has at 450° C less than half the strength which it possesses at normal temperatures. (See Plate 31, 2d Report, Alloys Research.)

Electrically deposited copper is less durable than commercial copper containing oxygen, when submitted to the corrosive action of sea-water.

By wrapping copper wire in iron wire or ribbon this corrosion is prevented, an action taking place in the formation of a protective deposit of iron oxide.

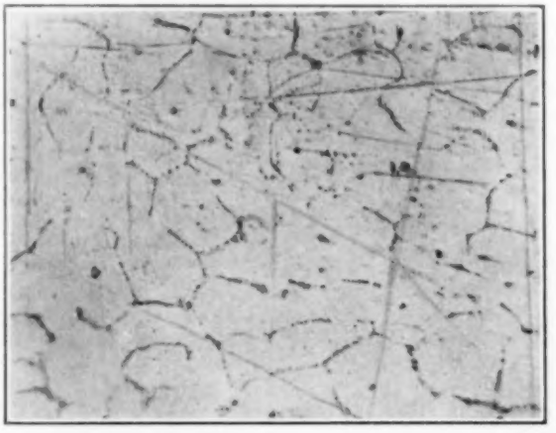


FIG. 8.—"TOUGH-PITCH" COPPER CONTAINING 0.08 PER CENT OXYGEN (0.7 PER CENT CUPROUS OXIDE).

The following micrographs illustrate how oxygen occurs in copper (in the form of cuprous oxide) from the stage of "set-copper," when poling is commenced, up to the stage of "tough-pitch." Heyn (Metallographist, Vol. VI. 1903, pp. 48 to 64) has shown that copper and Cu_2O are completely miscible when fused, but are mutually insoluble in the solid state. The accompanying micrographs show how the cuprous oxide in excess of that required by the copper to form an eutectic separates out first, in cooling, in the form of dendrites (of a blue color as viewed under the microscope). (See micrograph No. 6 showing Cu_2O dendrites surrounded by eutectic.) The eutectic point as seen in the curve given by Heyn corresponds with the presence of 3.4 per cent Cu_2O or 0.36 per cent oxygen. At this point the copper is completely saturated with Cu_2O, and, as seen under the microscope, is a uniform solid eutectic containing neither excess copper, nor excess cuprous oxide. (See micrograph No. 7.) Below this point copper crystals are the first to solidify and are surrounded by eutectic of later solidification. (Micrograph No. 8 of "tough-pitch" copper shows this clearly.)

Mr. Archbutt (Analyst, Vol. XXX, No. 357, December, 1905, p. 392) states that "the effect of the presence of oxygen in ordinary refined copper was to 'neutralize the injurious effect of certain other impurities, and a certain amount of oxygen was necessary in order to make the copper tough. A little more than was actually needed for that purpose would do no harm, and a difference of 0.05 per cent in the region of 0.15 per cent would be of no moment."

This may be true for fairly pure copper, but that there is such a wide range admissible in all kinds of commercial copper, varying as they do in the nature and properties of impuri-

ties, the writer feels bound to dispute. Some brands of copper exhibit infinitely greater sensitiveness in their susceptibility to suffer a loss of their best mechanical properties by a slight addition, or deprivation, of oxygen than others. It is all a question of what impurity or impurities the copper contains and in what proportion.

Segregation of Impurities.—There is no analogy, so far as the writer is aware, of any such segregation of impurities as occurs in steel and iron. The solvent action of molten copper is remarkable and absence of segregation would seem to strongly confirm a perpetuation of this property through a falling temperature. The rapid setting of copper castings also tends to limit any tendency for impurities to segregate. The precious metals, however, do segregate to a marked degree, quite sufficient to warrant very careful sampling (Heath, "Methods for the Complete Analysis of Refined Copper," J. Amer. Chem. Soc., Vol. 27, 1905).

To sum up, it may easily be seen from what has been said concerning the effect of impurities on copper that to systematically investigate their effect singly in measured quantities on copper containing the necessary oxygen to render it "tough-pitch" presents a vast field of research hitherto practically unexplored. When this has been completed, the work will have only been

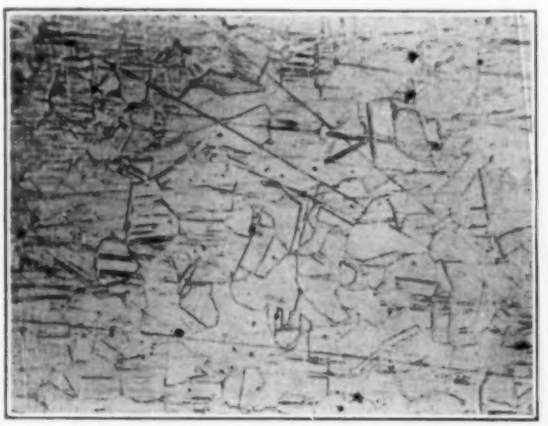


FIG. 9.—CAST COPPER COMPLETELY DEOXIDIZED.

commenced, for it will then be necessary to carry out similar experiments to demonstrate how these impurities behave in copper in the presence of another. As Dr. Watson (2d Report, Alloys Research) said: "The whole question of the proportion of oxygen which ought to be present in order to confer the best properties on copper containing various impurities had hitherto not been at all successfully investigated, so far as he knew. It was a subject presenting a really bewildering perplexity and involving difficult chemical analyses."

That pure copper or copper of more than usual purity, assaying, say, 99.8 per cent, is inferior to impure copper, both in mechanical properties, durability and resistance to corrosion has been made abundantly manifest from many independent sources. Webb has shown first that locomotive tubes of a purity of 99.8 per cent and over have proved to be far inferior in practice to tubes containing nickel or arsenic; secondly, that locomotive firebox stays behave satisfactorily when containing arsenic or tin. Dean proved that, on the whole, the purity of copper used in firebox plates was almost sufficient guarantee of its inferiority in practice. Roberts-Austen, Milton, Handscomb, Le Chatelier, Rudeloff and others have testified to the improvement in mechanical properties of copper conferred by the presence of traces of other metals.

The difficulty remains to show which impurities are most desirable, in what proportion, and the extent to which undesirable impurities may be present.

With regard to the effect of impurities on the electrical conductivity of copper, much research work has been done by Addicks and others. In this connection Sir W. Roberts-Austen, in a lecture delivered to the Institution of Civil Engineers, in 1902, said:

"I should have been glad, had time permitted, to deal with the improvements in the quality of copper used in electrical engineering. I will only say that if a metallurgist were now to offer to the electrical engineer such copper as was supplied in the middle of the past century, he would deserve to be relegated to the immortal pillory in which St. Paul placed Alexander, the coppersmith who did him much harm."

Electrolytic Chlorine at Mount Morgan, Queensland*

BY B. DU FAUR.

As the Mount Morgan electrolytic chlorine plant is the first of its kind installed in Australia, and as the details of this method of producing chlorine have, up to the present time, been kept more or less secret all over the world, the author trusts that this paper may fill a gap in the technical literature of the subject.

When an electric current is passed through a strong solution of sodium chloride the following reaction takes place: $2\,NaCl + 2\,H_2O = 2\,NaOH + Cl_2 + H_2$. Chlorine gas is liberated at the anode, while caustic soda and hydrogen are formed at the cathode. The all-important problem in designing an electrolytic chlorine cell is the provision of some effective means of isolating from each other the chlorine and caustic soda as soon as liberated from the electrolyte.

In the type of cell which has been given a severe test for efficiency and reliability at Mount Morgan the products of anode and cathode are kept apart by means of an asbestos cloth diaphragm within reasonable limits (for there must always be some interaction taking place through the diaphragm, though this may be kept within bounds).

The Cell.—Each cell (see Fig. 4) is divided into three compartments by means of two sheets of iron *b* perforated with small holes. These sheets are bolted to the bottom and ends of the cell by means of 1-in. angle iron. The two diaphragms *c* are placed over the inside walls, and extend right to the bottom of the cell. The bottom and two ends of the central or anode compartment are now covered with cement 1 in. thick so that no iron is exposed to the action of the chlorine liberated in this compartment. These diaphragms extend upward to the point *d*. They are held in position by the earthenware top *e* of the cell, the intermediate space being filled in with cement. The top piece *f* of the cell can be lifted off for the renewing of anodes from time to time, but while the cell is in commission it is kept perfectly gas-tight by covering the top of it with a coat of hot pitch. It hardens almost immediately and forms a perfect seal, not too difficult to remove.

The anodes *a* are of Acheson graphite from the International Acheson Graphite Company, of Niagara Falls.

The anode holders have a composition of 80 per cent lead and 20 per cent antimony. They are sweated into a hole bored in the top of the anode block. In the top of each holder a groove is cut, and into this groove the electrical conductor bar is sweated.

The glazed earthenware pot *g* is connected to the anode compartment by means of an ebonite pipe *k*, so that the level of the solution in this pot shows that of the solution inside the anode compartment. Each cell is electrically insulated from earth by means of a glass plate on the top of each supporting column.

Purification of the Electrolyte.—Before further describing the plant it will be necessary to state here that all commercial samples of crude sodium chloride, and nearly all natural waters, contain salts of calcium and magnesium. It is absolutely essential that these salts must never be allowed to get

*A paper presented at the Mount Morgan meeting of the Australasian Institute of Mining Engineers.

into the electrolytic cells, for there they would be immediately precipitated and soon close the cell completely.

The following is the scheme devised and successfully carried out at Mount Morgan for throwing these salts out of the brine solution before it reaches the cells:

A, in Fig. 1, is a galvanized-iron tank with a water pipe *Q* running horizontally across the bottom, and is itself pierced with holes. This tank is filled to within a foot of the top with crude salt. It is shoveled into the top of the tank from a platform, not shown in the figure. The water is now turned into the pipe *Q* and rapidly rises through the salt, dissolving it quickly until, on reaching the overflow spout to tank *B* it contains, on an average, 3 lb. of salt per gallon.

Throughout the time that the water is turned on one man is kept busy shoveling salt into the top tank *A* so rapidly does it dissolve.

In the top of the empty tank *B* has previously been placed 10 lb. of soda ash dissolved in a bucket of hot water, also ½ gal. of an 8 per cent caustic soda solution derived from the electrolytic cells. As the tank *B* fills with brine, an air hose, which extends to the bottom, is turned on slightly, thus keeping the whole well stirred until the tank is full. The air is then turned off, and the stream of brine from *A* diverted to the second mixing tank *B*, which is filled in a similar manner.

After being allowed to settle for two hours the thick white precipitate of calcium and magnesium hydrate has practically all settled down below the pipe *R*. This pipe is then opened and the comparatively clear solution run over into a settling tank *C*, where it is again left undisturbed for two hours.

The small amount of sediment carried over into tank *C* has now completely settled, and the perfectly clear brine, free from all precipitated lime or magnesium salts, is run through pipe *S* to the brine storage tank *D*, from which it is fed to the electrolytic cells.

This method of cleansing the electrolyte has been so successful that on opening the cells at the end of a six months' run without stop they were found to be practically free from precipitated lime and magnesia salts. Before this was resorted to it was found to be impossible to run the cells for more than three weeks without cleaning out the deposited salts.

There was left in tank *B* 18 in. of deposited salts, mixed with salt water, which latter has now to be extracted from the solid matter. This sludge is run out of the bottom of the tank into a wooden launder, which carries it on to the filter cloth of a vacuum filter *E*.

On starting the filter a vacuum is created beneath the cloth by sucking out the air by means of a steam ejector.

When the vacuum gage shows a vacuum of 23 in. of mercury steam is shut off, and a valve between the ejector and the filter closed, thus maintaining the vacuum. Experience has shown that this valve would hold the vacuum above 15 in. of mercury for half an hour, when by turning on steam for a minute it could be brought back to the original 23 in.

This filter filtered slowly (10 gal. per hour) owing to the exceedingly slimy nature of the precipitate, but, as it cost practically nothing to run, and could cope with the slime supplied to it, this did not matter.

The dry slime is shoveled off the filter cloth into a wheelbarrow on the floor and taken away.

Once a week it is found necessary to run the bottom portion of the solution in tank *C* into the filter also.

The clear brine filtrate from the bottom of the filter *F* is run into the brine storage tank *D*.

It is found that the calcium and magnesium contents of the crude salt varied enormously, and, as a regular amount of precipitant was at first run into each tank, it follows that there was sometimes an excess of precipitant and sometimes an excess of calcium and magnesium left in the solution. Therefore, the following method of testing the purified electrolyte was necessary:

From tank *B* a sample was taken, filtered, and divided into two portions to be tested, the one for excess of free alkali and the other for excess of calcium and magnesium salts.

Portion 1.—Take 25 c.c. in a flask and titrate with a decinormal solution of sulphuric acid, using methyl orange as an indicator. If the end points were reached before 0.6 c.c. of sulphuric acid had been added from the burette, the tank was passed as being sufficiently low in free alkali. This was equivalent to 0.024 grain of free caustic soda per gallon, or 2.86 lb. in the 24-hours' supply of 300 gal. If more than 0.6 c.c. sulphuric acid was used, more salt water from tank *A* was run into tank *B* to neutralize excess alkali.

Portion 2.—Add a few drops of soda carbonate solution and

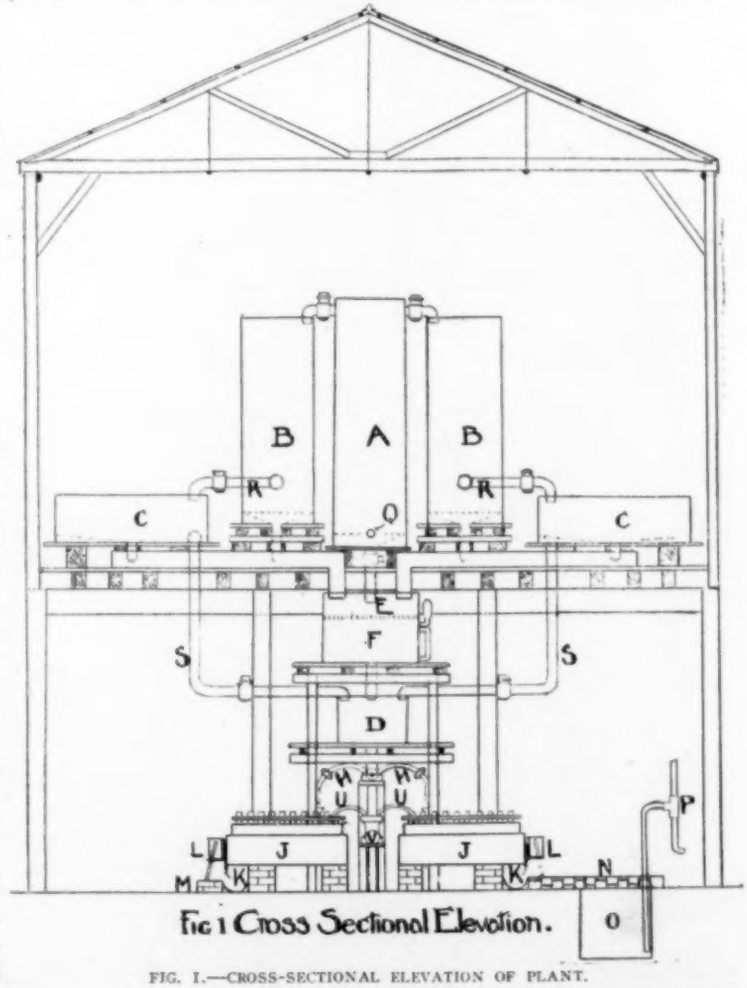


FIG. 1.—CROSS-SECTIONAL ELEVATION OF PLANT.

shake well; no precipitate shows absence of calcium salts. Add also a few drops of caustic soda solution and shake well.

If only a slight precipitate resulted the tank was passed as being good enough. If a heavy precipitate resulted more precipitant was added to tank *B* until it was found to be correct.

It is essential that not more than a certain amount of free alkali should be left in the purified brine, and so reach the anode compartment of electrolytic cell.

The results of a greater excess of free alkali in the anode compartment are:

The cells would start to supply oxygen instead of chlorine at anode, according to the following equation:

$$NaOH + H_2O = NaOH + H_2 + O.$$

The reason for this is that of the two compounds, caustic soda and sodium chloride, simultaneously present in the elec-

trolyte, the former will be first decomposed by the electric current.

The author has had this happen on several occasions, and was at a loss to understand the cause until, on testing the supply brine, he found too large an excess of free alkali present.

This combines partly with the chlorine, according to the following equations, forming sodium hypochlorite and sodium chlorate:

$$2\ NaOH + Cl_2 = NaCl + NaOCl + H_2O.$$

$$6\ NaOH + 3\ Cl_2 = 5\ NaCl + NaClO_3 + 3\ H_2O.$$

The presence of the former, at any rate, if not that of the latter also, causes rapid disintegration of the anodes.

The chief impurity in the salt was calcium sulphate, which is easily thrown out by the use of soda carbonate:

$$CaSO_4 + Na_2CO_3 = CaCO_3 + Na_2SO_4.$$

The magnesium chloride was partly got rid of by using caustic soda.

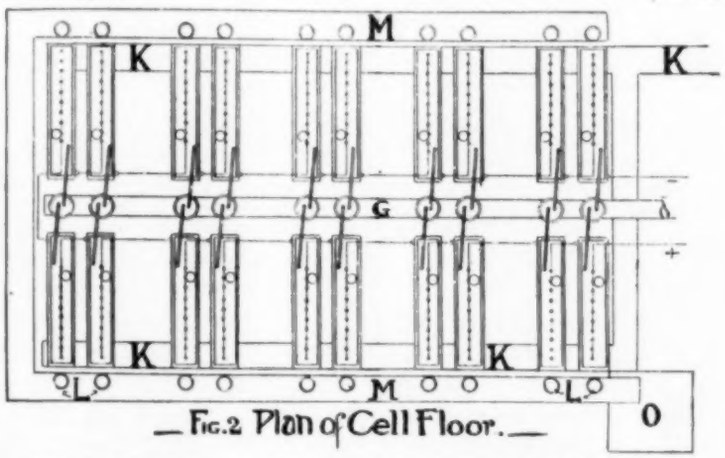


FIG. 2. PLAN OF CELL FLOOR.

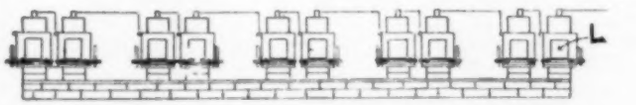


FIG. 3. SIDE ELEVATION CELL FLOOR.

FIG. 4. SECTIONS OF CELLS.

FIGS. 2, 3 AND 4.—HORIZONTAL AND VERTICAL SECTIONS OF ELECTROLYTIC CELL.

$$MgCl_2 + 2\ NaOH = Mg(OH)_2 + 2\ NaCl.$$

The purified brine from storage tank *D* drips into the anode compartment of each electrolytic cell by way of the glass funnels shown on top of the cells. Portion of this electrolyte passes through the diaphragms as caustic soda and undecomposed sodium chloride solution, leaving the cell via the movable arm *K*, which can be turned down to empty the cathode compartment at will.

The remainder of the electrolyte leaves the anode compartment by way of the porous pot *L*, and from there goes to the sump *O*. From there it is pumped up to a storage tank at sufficient elevation to force it through the salt-dissolving tank *A* again.

Chlorine gas is evolved at the anodes, and rising to the top of the compartment is drawn off by suitable means.

Hydrogen gas is liberated at the cathodes and escapes through the open top of the cell to the atmosphere, while the sodium set free at the cathode combines with the water present to form caustic soda, which leaves the cell in solution.

Salt Consumption.—The author has found that on a working scale where only chlorine is saved and caustic soda allowed to run to waste the production of 1 lb. of chlorine gas required 3 lb. of sodium chloride, dissolved in 1 gal. of water, to be fed to the electrolytic cells.

This sodium chloride is not absolutely pure, but in the following example we will take it as being so:

Then:

Chlorine present in 3 lb. sodium chloride..... = 1.80 lb.
Chlorine abstracted from sodium chloride..... = 1.00 lb.

Chlorine left as sodium chloride..... 0.80 lb.

This 0.80 lb. chlorine, representing 1.33 lb. sodium chloride, passes partly through the diaphragms and contaminates the caustic solution, and partly through the overflow pot *L*. If the caustic solution, which is not allowed to exceed 8 per cent in strength, is later on evaporated to produce strong caustic soda, this sodium chloride is thrown out of solution during the process and may be recovered. This would reduce the sodium chloride consumption per pound chloride produced from 3 lb. to 1.67 lb. If, on the other hand, the caustic soda is not evaporated, this salt is lost.

It has been found necessary to empty each cathode compartment of each cell once per 24 hours in order to keep the strength of the cathode liquors down to 8 per cent caustic soda. For, although the solution in the anode compartment stands at a slightly higher level than that in the cathode compartments, diffusion is always carrying a certain amount of cathode liquor into the anode compartment, and it follows that the stronger this liquor in caustic soda the more caustic soda gets into the anode compartment in a given time.

Evil Effects of Caustic Soda in Anode Liquor.—This caustic soda which finds its way into the anode liquors does harm in three different directions:

1. It reduces the available amount of caustic soda.
2. It reduces the available amount of chlorine.
3. The anodes are disintegrated and fall to powder, due to the presence of sodium hypochlorite and sodium chlorate, formed as shown previously.

It might be suggested that, if the rate of flow of electrolyte from anode to cathode compartment through the diaphragms were made great enough, the former would be kept free from caustic soda. Probably it would, but what would be the results? They would be:

1. Increased consumption of sodium chloride per pound chlorine produced.
2. Great loss of chlorine, due to the fact that the anode liquor, which is now passing rapidly into the cathode liquors, is saturated with chlorine gas, all of which becomes lost as available chlorine, besides also reducing the caustic soda yield.

Experience has shown that by keeping the caustic soda strength down to 0.8 lb. per gallon, or 8 per cent, a good output of chlorine and caustic soda is assured, though the anodes used become completely disintegrated after a continuous run of six months at a current of 350 amp, or 54 amp per square foot of anode surface.

Every six months the cells require to be opened for the introduction of fresh anodes and the clearing out of the disintegrated carbon. This disintegration of the carbon is common to all electrolytic chlorine cells using them. One American firm, however, claims to have found a method of reassembling the graphite dust into anodes again.

Power Consumption.—On starting the Mount Morgan plant with new anodes it was found that 88 volts were required to drive the 350 amp of current used through the 20 cells placed in electrical series. On the completion of the six months' run, when the anodes were nearly corroded away, the voltage had risen to 98.

This meant that the total electrical resistance of the plant had increased from 0.251 ohm to 0.280 ohm. Putting this in terms of electrical hp-hours of Board of Trade units, the total Board of Trade units required per 24 hours at the starting of the plant to give a certain daily output of chlorine were 739.20, while at the end of the run they had increased to 823.20.

Taking the cost of power at 1 d. (2 cents) per unit delivered at the switchboard, this meant that during the six months the cost of power per 24 hours had gradually increased from 739.20 d. ($14.78) to 823.20 d ($16.46).

Efficiency.—1. The efficiency of the plant taken on the basis of salt consumption per pound chlorine produced is 55 per cent, when the caustic soda is allowed to run to waste, while it becomes 99.80 per cent if it be saved. 2. The electrical current efficiency (amp-hour efficiency) is 63.72 per cent.

It may be said that this current efficiency is low, but it must be remembered that it was obtained by analyzing continuously the chlorine water actually delivered on the vats for leaching. This efficiency, therefore, covers all leakage of chlorine water tanks and loss of gas in chlorine water towers due to the insufficient supply of water at times.

3. The energy efficiency (watt-hour efficiency) was 49.24 per cent.

The technical data given in this paper will enable the reader to work out for himself the cost of producing chlorine in his particular locality by filling in the prices ruling there for the several commodities, such as power, salt, soda carbonate, wages, and water.

The above-described plant was run by four men, two on day shift and one on each other shift. These men could just as easily run a plant five times as large.

It is necessary that they should understand the duties of a dynamo attendant and be capable of being taught how to carry out the volumetric assays for chlorine water and caustic soda strengths.

In conclusion, the author would like to point out that since power is the main item of expense in the working of this process it follows that this power must be obtained at a reasonably cheap rate. To obtain this the dynamo must be directly driven, either by a steam engine or by a suction gas-producer plant. If electrical power has to be conveyed any considerable distance it is well known that the losses in transmission and transformation are so great as to put transmission out of consideration when comparing it with either of the above methods.

Except for water-power suction gas is now undoubtedly the cheapest available and most reliable source of power. The makers of many plants are now willing to guarantee a fuel consumption of coke of not more than 1.30 lb. per brake hp-hour, delivered by the engine, when running on full load. Consequently, when considering the installation of an electrolytic chlorine plant, the author strongly recommends suction gas as the source of power.

Hardness and Its Measurement.

By G. A. Roush.

The physical property termed *hardness* has been defined in several different ways, and many different methods have been devised to measure it. Owing to the fact that hardness is in itself not a definite property, but the result of a combination of several different properties, this has given rise to results that are comparative only in a small degree, since the operation of one of the methods may depend on the measurement of an entirely different property or set of properties from some other method.

For example, it is evident that the elasticity and ductility of a material form a larger factor in the test where hardness is defined as the resistance of a body to permanent deformation than where hardness is defined as the resistance to penetration by another body. Hence the desirability of analyzing the exact components of any hardness tests that may be applied, and establishing such relations between these components that definite conclusions can be drawn from the results obtained. This is, however, a matter of considerable difficulty, and has not yet been accomplished.

Recent investigations have shown results pointing to a definite relation of this kind, but just exactly what it is cannot yet be stated. The object of this paper is the comparison of the hardness data[1] and the other physical tests[2] on the alloys of nickel, copper and Monel metal with electrolytic iron that have been made in the Chemical Engineering Laboratories of the University of Wisconsin, working under grant from the Carnegie Institution.

As has been said, the relative hardness of any material varies with the kind of stress to which it is subjected. The different properties which apparently may enter into and influence the results obtained by the different methods of testing are density, elasticity, ductility and tenacity. The degree in which these properties, taken in combination, are affected by the stress applied determines the hardness of the material under these conditions. One and the same metal may show an entirely different degree of comparative hardness, depending on which of these components predominates in the final result, and a metal that is shown harder than another by one method may be softer when tested by a different method.

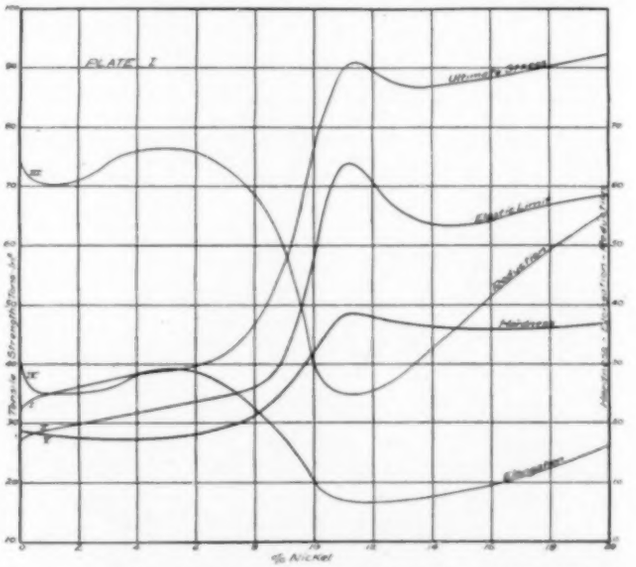


FIG. 1.—TENSILE STRENGTH AND HARDNESS OF FORGED NICKEL ALLOYS.

A series of samples arranged according to increasing hardness as measured by machining in a lathe will not necessarily remain in the same order when tested by a compression method. On this basis Turner[3] divides hardness into four different classes—tensile hardness, cutting hardness, abrasion hardness, and elastic hardness.

The method used for determining the hardness in the investigations cited was the scleroscope method devised by Albert F. Shore in 1906, and is described as follows: "The instrument consists of a vertical glass tube provided with a graduated scale, suspended over a steel anvil on which the sample to be tested is placed; a small steel plunger with a diamond point, suspended in the top of the tube, is allowed to drop on the

[1] *Met. and Chem. Eng.*, (a) p. 468, Aug., 1910; (b) p. 522, Sept., 1910.

[2] (a), Physical Properties of Iron-Copper Alloys, Burgess and Aston, *Trans. Amer. Electrochem. Soc.*, 16, 241-256, 1909; (b), The Magnetic and Electrical Properties of Iron-Nickel Alloys, Burgess and Aston, *Met and Chem. Eng.*, 8, 23-26, 1910; (c), The Magnetic and Electrical Properties of Iron-Copper Alloys, Burgess and Aston, *Met. and Chem. Eng.*, 8, 79-81, 1910; (d), The Strength of the Alloys of Nickel and Copper with Electrolytic Iron, Burgess and Aston, *Bull. Univ. of Wis.*, Eng. Series, Vol. 6, No. 2; (e), The Strength of the Alloys of Electrolytic Iron and Monel Metal, Burgess and Aston, *Met. and Chem. Eng.*, 8, 452-456, 1910.

[3] *Jour. Iron and St. Inst.*, 1909, (1), p. 426.

sample clamped on the anvil, the rebound of the plunger being read off on the scale at the back of the tube. When the plunger reaches the surface of the metal under test it carries a certain amount of potential energy, and the weight of the plunger, the height of the fall and the area of the striking surface are so proportioned that in all cases this energy is sufficient to exceed the elastic limit of any material which may be under test.

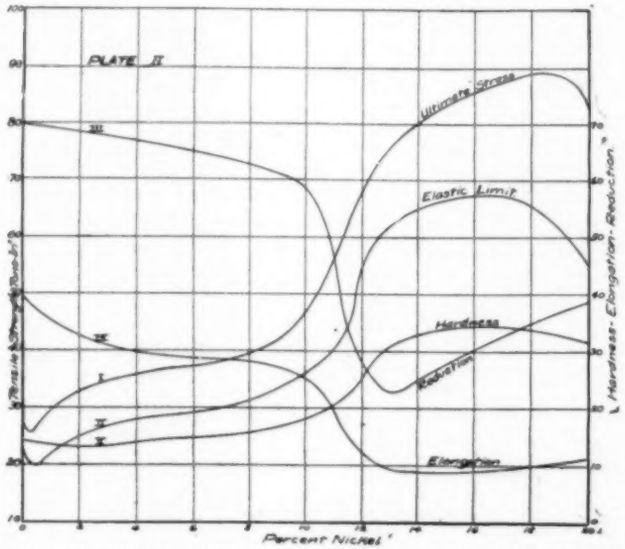


FIG. 2.—TENSILE STRENGTH AND HARDNESS OF ANNEALED NICKEL ALLOYS.

"This being the case, the material on receiving the impact of the plunger is stressed beyond its elastic limit and given a permanent deformation. If the elastic limit of the material under test is high, the excess energy of the plunger is small and only a small dent is made on the surface. That portion of the material immediately adjoining the deformed portion has then been stressed only up to its elastic limit, and in regaining

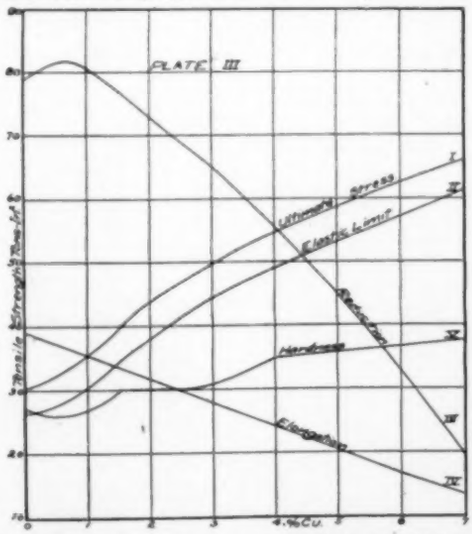


FIG. 3.—TENSILE STRENGTH AND HARDNESS OF FORGED COPPER ALLOYS.

its original form causes the plunger to rebound a certain distance. If the metal under test has a low elastic limit a smaller portion of the energy of the falling plunger is used in overcoming the elasticity, and a greater portion is used in displacing metal. The stress of the adjoining metal is then only sufficient to give the plunger a small rebound. This rebound is then taken to represent the hardness of the material under test."

Basing his conclusions on this line of reasoning, Shore makes the statement[4] that the curve of hardness as determined by the scleroscope is very nearly parallel to the curve of elasticity, but since the value obtained in any test for hardness is the resultant

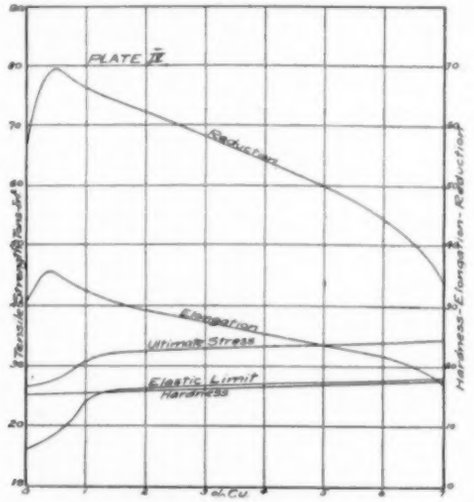


FIG. 4.—TENSILE STRENGTH AND HARDNESS OF ANNEALED COPPER ALLOYS.

of the different factors mentioned above it can be seen that this will be true only when those factors other than elasticity enter into the result to a very small extent, and that frequently the variation will be large.

Reference may also be made here to the statement made in the first paragraph of this paper in relation to the different properties affecting a hardness test, and the interpretation of

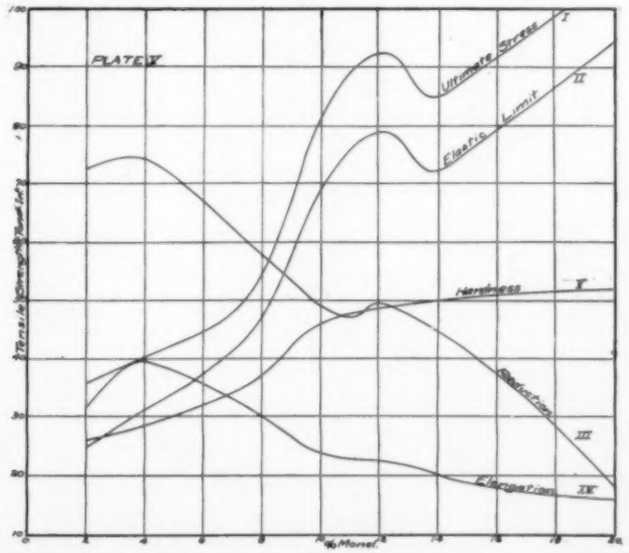


FIG. 5.—TENSILE STRENGTH AND HARDNESS OF FORGED MONEL ALLOYS.

the results for different purposes. In the article by Burgess and Aston referred to above[5] the iron-nickel alloys between 11 and 20 per cent are classed simply as "hard," no reference being made to any particular difficulty in machining, while the copper alloys above 5 per cent are said to have been machined with difficulty. The comparative hardness of the copper alloys, however, as measured by the scleroscope, is some 25 per cent lower than the nickel alloys.[6]

The comparison of the hardness curves with other tests that

[4] *Amer. Mach.*, Nov. 14, 1907.
[5] See reference above, 2d, pp. 10 and 20.
[6] See reference above, 1a, Tables I and III.

have been made on the same materials is a matter of considerable interest. In Figs. 1 to 6 are reproduced the hardness curves for the nickel, copper and Monel alloys referred to,[7] along with the tensile tests on the same bars taken from the articles by Burgess and Aston cited above.[8] In each of these plates curve number I is the ultimate stress, II is the elastic limit, III is the reduction of area, IV is the elongation and V is the hardness.

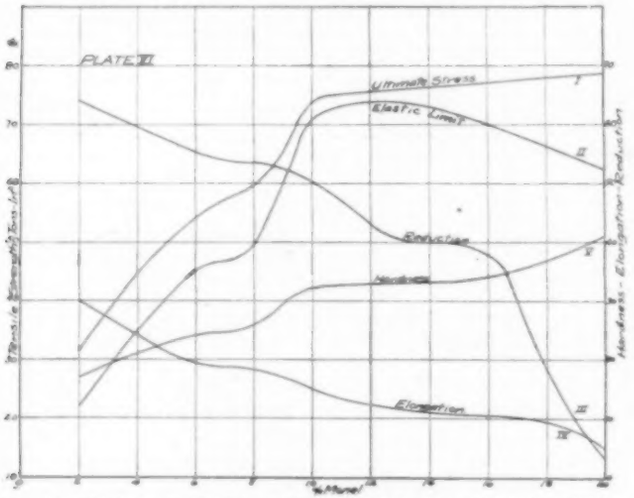


FIG. 6.—TENSILE STRENGTH AND HARDNESS OF ANNEALED MONEL ALLOYS.

As has been said, the hardness curve roughly approximates the general direction of the curve for the elastic limit, but in many points there is a wide difference. If the two curves followed each other exactly, it would be a simple matter to plot a curve showing the relationship between the two, which could be used to convert hardness tests directly into tests on elastic limit.

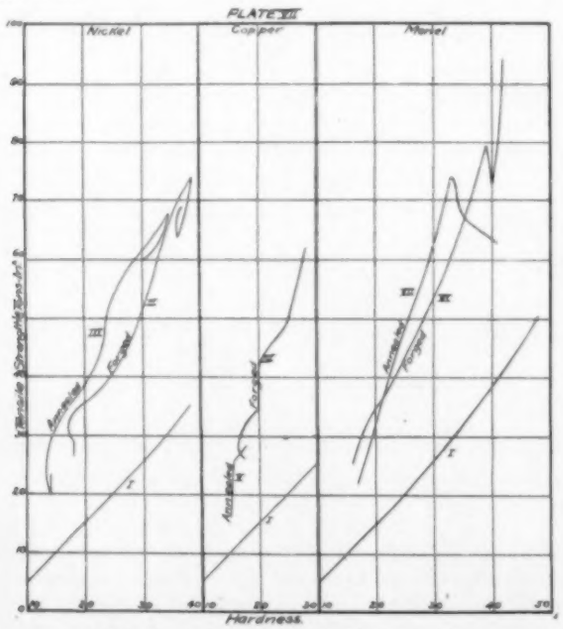


FIG. 7.—STRENGTH-HARDNESS CURVES.

Among the data sent out with the scleroscope by the manufacturers is a table for converting hardness into elastic limit. This table is said to serve as a means of obtaining the strength tests on all metals below a hardness of 60, except cast iron and brittle alloys such as those of antimony. The data in this table are plotted in graphical form in curve I, Fig. 7. This shows a simple relationship between the hardness and the elastic limit varying only slightly from a straight line function. This curve is obtained by plotting hardness as abscissæ and elastic limit as ordinates.

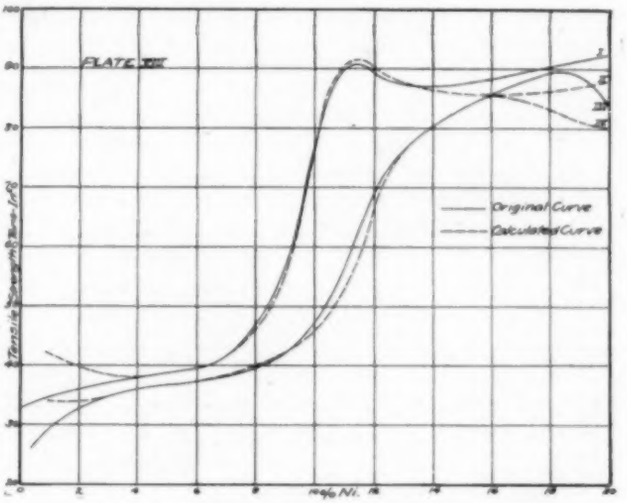


FIG. 8.—ULTIMATE STRENGTH OF NICKEL ALLOYS.

The relations between the hardness and the elastic limit as shown by the curves in Fig. 1 to 6 fail, however, to follow any such simple relation as this, nor are the values obtained at all close to those obtained by Shore. Furthermore, each one of the six series tried out here gives a different relation, and not one simple relation for all.

Curves II and III of Fig. 7 show respectively the results obtained by plotting in this same way the hardness and elastic limit of the forged and annealed nickel alloys; curves IV and V are from the forged and annealed copper alloys, and curves VI and VII from the forged and annealed Monel alloys.

In the nickel and Monel series the shape of the curves for the forged and annealed samples is not radically different, showing that the existing relations between the hardness and elastic limit are not materially changed by annealing the material, but in the copper series the change is quite marked.

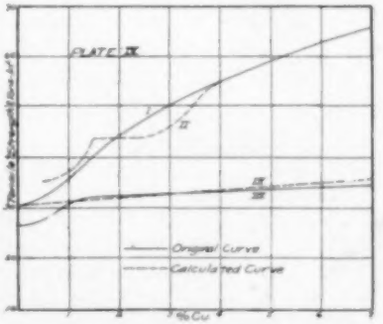


FIG. 9.—ULTIMATE STRENGTH OF COPPER ALLOYS.

A comparison of the hardness curves with those of elongation and reduction of area shows that it is the ductility of the material that causes the greater part of the variation of the hardness and elastic limit curves. Since the difference between the elastic limit and the ultimate strength depends to a certain extent on the ductility of the material it is probably more nearly correct to compare hardness with ultimate strength rather than with elastic limit. Following out this idea the attempt was made to reproduce the ultimate strength curves from the hardness curves, with the results shown in Figs. 8, 9, 10.

A conversion factor was obtained by dividing the ultimate strength shown at the middle of the curve by the hardness at the corresponding point, and this factor was then used to convert the remaining points on the hardness curve into values for ultimate strength. In each case the original curve for the forged samples is number I and the calculated curve is num-

[7] See reference above, 1a and b.
[8] See reference above, 2d and e.

ber II; the original curve for the annealed samples is number III and the calculated curve is number IV. These conversion factors, of course, differ somewhat for the different materials, but the variation is not as large as might be expected. The factors are as follows:

For forged nickel	2.38
For annealed nickel	2.60
For forged copper	2.38
For annealed copper	2.02
For forged Monel	2.25
For annealed Monel	2.30

None of the curves calculated in this way coincide throughout with the original, but they fall close enough to be of value in noting the points where the variations come, and may, in the light of further data, help in the location and evaluation of the factor or factors that are lacking to make the two curves duplicates.

It appears then that the scleroscope gives measures of hardness only approximately proportional to the elastic limit of the material, and will require individual calibration curves for each series of alloys in order that its readings may be resolved into values for strength. Six partial curves are given herewith in Fig. 7.

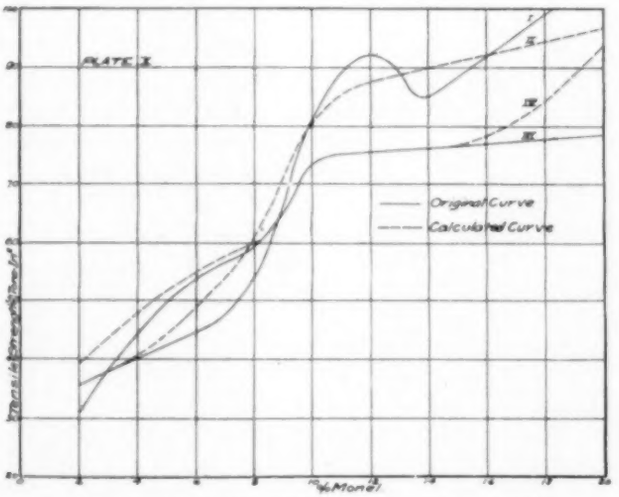


FIG. 10.—ULTIMATE STRENGTH OF MONEL ALLOYS.

While the results shown here point to the existence of a definite relation between hardness and elastic limit or ultimate strength, it appears that this relation is of such a complicated nature as to require further data than are now at hand to determine its exact nature and reduce it to mathematical terms.

University of Wisconsin,
Madison, Wis.

Gas Engines.—From the Pittsburgh office of the Bessemer Gas Engine Company, Grove City, Pa., comes a catalog illustrating their line of gas engines and auxiliaries. The Bessemer design has several distinctive features and might best be described as "different." The engine is two-cycle, thus getting a power impulse at every stroke, and uses a cross-head to reduce cylinder wear. The combustion chamber is valveless and the single valve used is not exposed to high temperature or pressure. Sizes are from 5 hp to 150 hp, the single, horizontal type running from 5 hp to 60 hp and twin cylinder 35 hp to 150 hp. Natural gas and producer-gas designs are furnished for commercial work and special lines for oil-field and electric light service. In addition to gas engines a line of direct gas-engine driven air and gas compressors, and direct-driven small pumps, also a separately driven triplex pump in sizes from 10,000 gal. to 500,000 gal. of water per day, are shown in the catalog.

A Convenient and Inexpensive Furnace for Very High Temperatures.

BY D. F. CALHANE, PH.D.

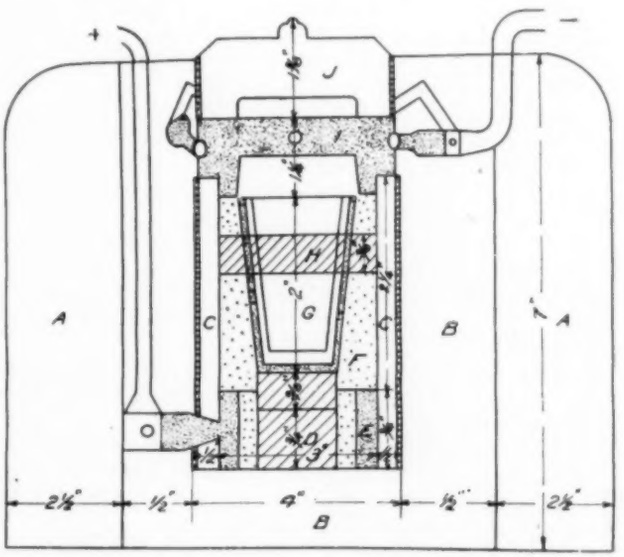
In an article by Pip in the August 15th number of the *Zeitschrift für Elektrochemie* is described a small furnace for high temperature work.

It occurred to me that a description of a furnace that I have used for the past two years in my laboratory might be of interest.

Some two years ago, in connection with work on nickel alloys, I had occasion to employ high temperatures, over 1500° C. It was especially desired to obtain the melts without carbon contamination. In the furtherance of this work, the following simple and efficient furnace was devised.

Referring to the figure:

A shows the ends of two fire-bricks. Four of these were



A. Fire Brick
B. Portland Cement Magnesia Oxide + Asbestos.
C. Fire Clay Muffle Iron Band
D. 2 Alundum Blocks
E. Carbon Ring
F. Powdered Carbon
G. Alundum Lined Graphite Crucible
H. Alundum Insulating Ring
I. Graphite Ring
J. Fire Clay Cover

LABORATORY ELECTRIC FURNACE.

employed to form the outside of the furnace. The two end bricks were cut down to give the proper width to the body of the furnace.

C represents the cross-section of a small fire-clay muffle, such as is sold by the Buffalo Dental Company in connection with its No. 40 Fletcher's crucible furnace. This sets inside the enclosure formed by the fire brick and the extra space is filled with a heat-insulating composition composed of Portland cement, magnesium oxide and powdered asbestos. This is shown by B in the figure.

At the bottom of the muffle is placed an alundum block D. On this rests a No. O graphite crucible, shown by G in the figure.

In this graphite crucible is cast an alundum lining, which keeps the melts from carbon contamination.

The current enters by the lead at the bottom of the furnace, and is evenly distributed by a graphite ring E, that fits flush at the bottom of the muffle. This ring was cut from an odd end of a graphite electrode. The graphite electrodes lend themselves to this kind of work, as they are easily machined whereas carbon is not.

The carbon resistor is denoted by F. This is composed of carbon powder obtained from the National Carbon Company. H is an alundum ring, that is doughnut-shaped. The inner hole is filled to within about ¼ in. around by the crucible.

This design gives a simple method of insulating the main portion of the resistor, and directs the current flow along the walls of the crucible up through the ring between the wall of crucible and inner edge of the ring. Herein lies the high efficiency of the furnace. Intense heat is concentrated where it is wanted, namely on the walls of the crucible. By varying the area of the space between the crucible and inner side of the ring, and the height of the block D, the voltage and wattage of the furnace can be varied widely.

On the top of the muffle sets a graphite ring I, also made from an electrode end. This ring has contacts screwed in as shown, connected with leads for the exit of the current.

On the upper edge of the ring sets the cover of the muffle J. The top, from the upper surface of the fire bricks over to the edge of the cover J, is built up with the same insulating mixture used at B, and is fashioned to give a symmetrical outline to the furnace. The whole outside may be painted with water white to give a neat appearance. The whole body of the furnace rests on a cement base that is contained in a shallow, oblong box. The furnace can be thus carried about, as the whole thing weighs only about 25 lb.

A couple of examples showing the efficiency of the device may be of interest:

In one case the heat-resistivity of the device was pushed to the limit. For this size furnace 1330 watts were found to produce a temperature that fused alundum and must have been over 2500° C. In this experiment the furnace absorbed 70 amperes at 19 volts.

In another instance the furnace was calibrated with a platinum-iridium thermocouple and galvanometer up to the limits of this apparatus, namely 1600° C.

The results showed that at 700 watts a temperature of 1600° C. was recorded by the pyrometer. A rough extrapolation on this basis to 1330 watts would indicate a temperature in the neighborhood of 2800° C.

It might be asked how such a temperature could be attained without melting down the alundum completely. The answer is that the intense heat zone is only along the walls of the crucible, where no alundum is directly in contact.

A furnace on the above lines of 6 kw capacity will soon be in use here.

The cost of the size of furnace above described is very little. The graphite portions can be turned out on the lathe from electrode odds and ends by anyone who can operate a lathe. The muffle costs about $1.00. The alundum portions, that is the block, crucible lining and ring, were made by the Norton Company. The whole affair should not cost over $4.00 at most.

Sixty to seventy grams of metal may be melted in the 1-kilowatt size.

Worcester Polytechnic Institute,
Electrochemical Laboratory.

Electro-Metallurgy in Switzerland.—According to the London *Electrical Review* a group of important French and Swiss bankers have opened a credit of $1,600 000 to the Société Electro-metallurgique Paul Girod, of Neuenburg, in order to render it possible for the undertaking to unify its current liabilities and extend its plant. The Franco-Swiss banking group which has turned attention to the Girod Company is under the lead of the Société Marseillaise de Credit Industriel et Commercial, which occupies itself specially with enterprises engaged in the metal industry. A French subsidiary of the Girod company—the Compagnie des Forges et Chantiers de la Mediteranee of Ugine—was formed some time ago with a share capital of $800,000, which is held by the Swiss parent concern, and the company has been able to secure large orders from the French naval and military authorities.

The Chemical Import Trade of Germany.

By W. Pollard Digby.

Supremacy by any country in any manufacturing sphere involves a relatively small import trade in the commodities produced by the group of manufactures concerned. An import trade may and often does exist, such a trade being a subordinate one in the sense of affording to the works raw or partially manufactured material, which undergoes further treatment and becomes a finished article either for local consumption or for re-export. The import trade may also cover identical rival commodities entering to a small extent only and dependent for its persistence upon special conditions, such as cheap freights between the points of production and consumption.

After having discussed the chemical export trade of Germany we will now deal with its chemical import trade, considering the total chemical import trade of Germany for the 10 years ending 1908:

1899	$79,066,250
1900	82,841,250
1901	82,898,250
1902	80,716,750
1903	87,704,250
1904	94,407,000
1905	107,712,500
1906	109,431,000
1907	95,112,500
1908	88,550,750

the total value is about 75 per cent of that of the total chemical exports (Fig. 1). But very nearly one-third of the imports

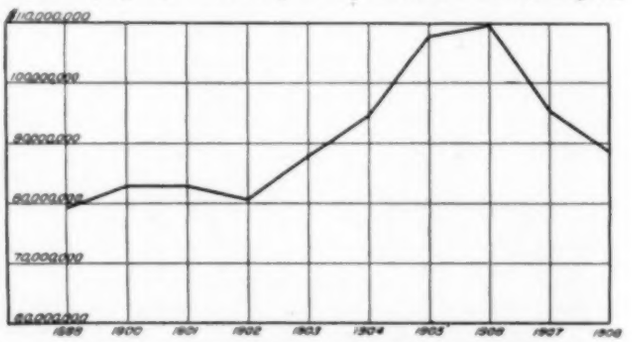


FIG. 1.—TOTAL CHEMICAL IMPORTS OF GERMANY.

consist of sodium nitrate, which, while classified correctly as an article of a chemical nature, serves to assist no other industry than that of agriculture by enriching the poor and sandy soil so familiar to all who travel through northern Germany.

Examining in detail the leading items and their origin the following data have been compiled from the official publications:

Sulphuric Acid.—The imports of sulphuric acid increased rapidly till in 1906 they exceeded the value of the exports. Although in the depression of 1907-08 imports declined, they are still in excess of the exports.

	1904.	1905.	1906.	1907.	1908.
Great Britain	.....	.....	.....	.....	.....
Rest of Europe	$175,000	$375,000	$908,250	$740,750	$760,500
United States	.....	.....	.....	.....	.....
Brit. No. Amer.	.....	.....	.....	.....	.....
Other Brit. Col.	.....	.....	.....	.....	.....
South America	.....	.....	.....	.....	.....
Rest of World	.....	.....	9,750	6,250	7,000
Total	$175,000	$375,000	$917,000	$747,000	$767,500

Caustic soda, soda ash and caustic potash.—While, as shown on page 465 of this journal, the total exports of these three commodities reached some $3,900,000 in value, the import trade is entirely negligible, amounting in 1908 to $5,500 for caustic soda, $6,500 for soda ash and $3,750 for caustic potash.

Bleaching Powder.—Imports of bleaching powder are also negligible, the total value in 1908 being $33,000.

Copper Sulphate.—The import trade has in 1907 and 1908 exceeded the total value of the exports. Fig. 2 shows the fluctuation of the imports.

	1904.	1905.	1906.	1907.	1908.
Great Britain...	$50,000	$100,000	$50,750	$418,000	$420,500
Rest of Europe.	50,000	75,000	51,250	104,250	62,000
United States..	50,000	50,000	96,750	.....	.....
Brit. No. Amer.	.....	.....	.....	.....	.....
Other Brit. Col.	.....	.....	.....	.....	.....
South America.	.....	.....	.....	.....	.....
Rest of World..	25,000	25,000	25,500	132,750	20,250
Total.....	$175,000	$250,000	$224,250	$655,000	$502,750

Sodium and Potassium Sulphates.—Here, again, the import trade is small, and the tables scarcely worth reproduction. Imports of sodium sulphate reached their maximum value of $78,250 in 1907 and declined to $33,000 in the succeeding year. Potassium sulphate was valued at $6,250 in 1908.

Sodium and Potassium Nitrate.—These two commodities, in which a fair re-export trade is carried out, account, as already pointed out, for a large proportion of the total value of the imports. Fig. 3 shows the import trade in sodium nitrate, the source of which is wholly South America.

Sodium Nitrate:

	1904.	1905.	1906.	1907.	1908.
Great Britain...	.....	.....	.....	.....	.....
Rest of Europe.	.....	.....	$42,750	.....	.....
United States..	.....	.....	9,000	.....	.....
Brit. No. Amer.	.....	.....	.....	.....	.....
Other Brit. Col.	.....	.....	.....	.....	.....
South America.	$24,650,000	$27,675,000	31,137,000	$31,785,250	$29,152,750
Rest of World..	25,000	50,000	20,500	17,500	12,250
Total.....	$24,675,000	$27,725,000	$31,209,250	$31,802,750	$29,165,000

Potassium Nitrate:

	1904.	1905.	1906.	1907.	1908.
Great Britain...	.....	.....	.....	.....	.....
Rest of Europe.	$225,000	$250,000	$198,250	$196,500	$231,500
United States..	.....	.....	.....	.....	.....
Brit. No. Amer.	.....	.....	.....	.....	.....
Other Brit. Col.	.....	.....	.....	.....	.....
South America.	.....	.....	.....	.....	.....
Rest of World..	.....	.....	15,750	7,750	10,500
Total.....	$225,000	$250,000	$214,000	$204,250	$242,000

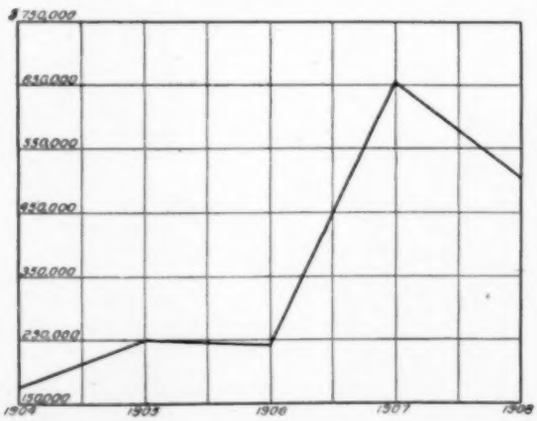


FIG. 2.—IMPORTS OF COPPER SULPHATE TO GERMANY.

Carbonate of Potash.—Small supplies are obtained from adjacent countries as indicated below.

	1904.	1905.	1906.	1907.	1908.
Great Britain...	.....	.....	.....	.....	.....
Rest of Europe.	$100,000	$100,000	$143,500	$175,000	$128,000
United States..	.....	.....	.....	.....	.....
Brit. No. Amer.	.....	.....	.....	.....	.....
Other Brit. Col.	.....	.....	.....	.....	.....
South America.	.....	.....	.....	.....	.....
Rest of World..	25,000	25,000	8,750	9,250	5,000
Total.....	$125,000	$125,000	$152,250	$184,250	$133,000

Aniline Dyes and Indigo.—The imports of aniline dyes and indigo are small in volume. The former represents about 4 per cent of the value of the export trade under this head, while the indigo imports, never large, fell in 1908 to about two-thirds of their value in 1904, and represented only about 2½ per cent of the exports.

Aniline Dyes:

	1904.	1905.	1906.	1907.	1908.
Great Britain...	.....	$100,000	$176,700	$116,250	$75,750
Rest of Europe.	.....	1,075,000	1,145,250	1,159,500	968,250
United States..	.....	.....	16,750	.....	.....
Brit. No. Amer.	.....	.....	.....	.....	.....
Other Brit. Col.	.....	.....	.....	.....	.....
South America.	.....	.....	.....	.....	.....
Rest of World..	.....	25,000	31,500	34,000	28,750
Total.....	.....	$1,200,000	$1,370,000	$1,309,750	$1,072,750

Indigo:

	1904.	1905.	1906.	1907.	1908.
Great Britain...	$25,000	$25,000	$29,750	$18,000	$29,750
Rest of Europe.	25,000	50,000	.....	.....	.....
United States..	.....	.....	.....	.....	.....
Brit. No. Amer.	.....	.....	.....	.....	.....
Other Brit. Col.	150,000	125,000	68,250	86,750	110,500
South America.	75,000	25,000	.....	.....	.....
Rest of World..	75,000	75,000	109,250	166,000	80,250
Total.....	$350,000	$300,000	$207,000	$207,750	$220,500

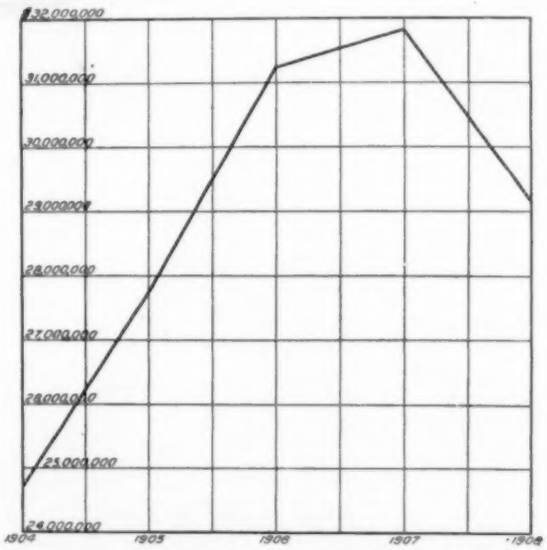


FIG. 3.—IMPORTS OF SODIUM NITRATE TO GERMANY.

Ammonium Sulphate.—The imports of ammonium sulphate have been fairly steady in value, Great Britain almost regaining in 1908 the total value supplied by her to Germany in 1905.

	1904.	1905.	1906.	1907.	1908.
Great Britain...	$1,100,000	$1,675,000	$767,500	$843,750	$1,494,750
Rest of Europe.	1,025,000	1,275,000	1,172,500	1,239,000	1,337,750
United States..	.....	.....	.....	.....	.....
Brit. No. Amer.	.....	.....	.....	.....	.....
Other Brit. Col.	.....	.....	.....	.....	.....
South America.	.....	.....	.....	.....	.....
Rest of World..	75,000	100,000	270,250	12,500	3,500
Total.....	$2,200,000	$2,950,000	$2,210,250	$2,095,250	$2,836,000

This brief article covers the small import trade of Germany in chemical substances. Only the leading imports have been described. There are, of course, numerous minor items, but these do not merit separate mention. Deducting nitrate imports the remaining balance bears a small proportion to the German exports. The forces which have tended to produce this end were briefly indicated in the August issue of this journal.

The increased use of cement is noted in a report issued by the U. S. Geological Survey. More cement was made and used in 1909 than in any other previous year, and the price per barrel was also lower. The production in 1908 was 52,910,925 barrels valued at $44,477,653; in 1909 the production was 64,196,386 barrels valued at $51,232,979. The average price of Portland cement in 1909 was less than 81 cents per barrel as against 85 cents in 1908. There were 103 Portland cement plants in operation in 1909 in this country, an increase of 5 over 1908.

Modern Hydrometallurgy in Australia.

By J. R. Masson and J. E. Edwards.

Hydrometallurgy has made such rapid strides during the past few years that it may be said to be almost, if not quite, the universal method of treatment for gold and silver-bearing ores. Although the original principle of the cyanide process still remains, there are more up-to-date methods of application being introduced every day. Rapid extraction and quick separation of the solution have long been aimed at, and these problems have been solved.

A short sketch of Australian experience will make this clear. The old treatment of heavy sulphide ore was as follows:

1. Crushing (wet).
2. Concentrating.
3. Roasting of concentrate.
4. Chlorination of roasted concentrate.
5. Separation of sand and slime from residue after concentration.
6. Cyanidation of sand by percolation.
7. Cyanidation of slime by agitation.
8. Filter pressing of slime.

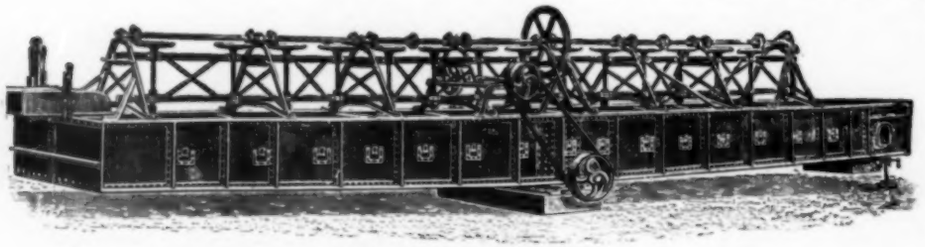


FIG. 1.—TILTING TYPE.

More recently the treatment has been considerably simplified, owing to the development of mechanical devices which will be described later, and now consists of:

1. Crushing.
2. Roasting.
3. Agitation of sand and slime together in cyanide solution.
4. Filtration of solution.

The ore is usually crushed to 30 mesh, roasted in Edwards furnaces and then agitated with cyanide solution in A. Z. agitators. Until this agitator was introduced the above method was not possible, as never before had there been a machine capable of mechanically agitating and aerating sand and slime together. The great advantage found in the agitation of the combined products is that a quick separation of the cyanide solution is easily accomplished, and may be made in an ordinary percolation vat. The most up-to-date method however, is to discharge the contents of the agitator into what is known as the Edwards rapid filtration tank, in which the solution is driven through and separated from the treated ore under pressure. This simple method is giving every satisfaction and is very rapid.

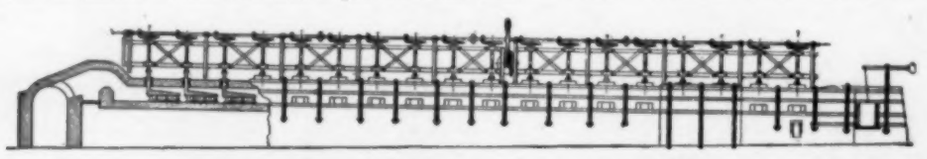


FIG. 3.—SIDE ELEVATION OF FIXED HEARTH TYPE.

Roasting.

In the design of mechanical roasting furnaces certain desirable conditions of operation and proportions in construction have been adapted from the old-fashioned hand-rabbled furnace. The correct height of arch, the proper relation of width of hearth to height of arch, and the elimination of dead spaces are the important features sought and attained in the Edwards furnace. It has a rabbling mechanism which permits of the construction of a low arch, so that the most economical application of the heat is obtained. The advantage of this is found in lower fuel cost, more complete oxidation of the ore, and more even distribution of heat over the hearth.

The dead space in this furnace is confined to small triangular areas next the walls, similar to the spaces between the side doors of the hand-rabbled furnace. The intersection of the circular paths of the rabbles in the Edwards furnace provides for effective agitation of the ore, at the same time advancing it gradually toward the discharge end. Another point in the construction of this furnace is the provision for the introduction of air wherever necessary in order to effect the most complete oxidation. This is accomplished by arranging numerous doors along the sides of the furnace. All of these considerations make the furnace most effective in the roasting of sulphide and sulpho-telluride ores prior to treatment by cyanidation or chlorination.

Two different types of furnace are made, that known as the simplex having but one row of rabbles, and the duplex having two rows. These two types are built in different forms, known as the tilting (shown in Fig. 1) and the fixed hearth,

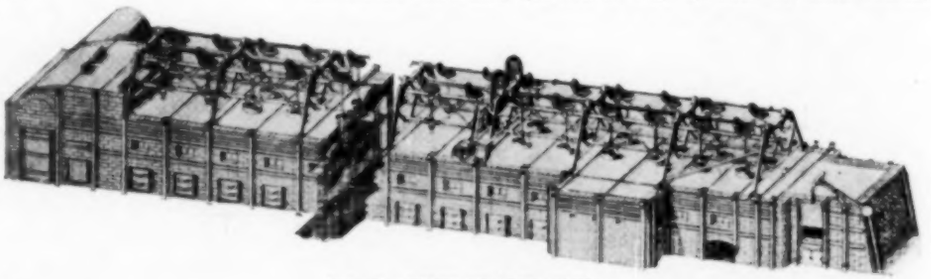


FIG. 2.—FIXED HEARTH TYPE.

Fig. 2. The former is built of steel lined with brick, and is balanced at its center support and can be adjusted to any desired slope of hearth. The latter, as its name implies, is of fixed reverberatory construction.

As shown in Figs. 3 and 4, which are respectively side elevation and plan of the duplex fixed-hearth type, the rabbles consist of horizontal arms with depending teeth. Each rabble is attached to a vertical spindle which projects through the arch of the furnace. The spindles are actuated by gear mechanism on top of the furnace so adjusted that each rabble rotates in direction opposite to the next, and the circle of rotation of one rabble intersects that of the next adjoining rabble. In the duplex furnace the intersections also occur between the two rows of rabbles. The rabble and that portion of the spindle which is within the furnace is cooled by a positive circulation of water.

The Edwards furnace is most widely used in Australia, but has also met with a favorable reception in this country, where it is in use at large plants treating both sulphide and sulpho-telluride ores. The customary size of the tilting type is 57 ft. x 6 ft. 6 in., and of the duplex fixed hearth type, 100 ft. x 11 ft. The power required

varies with conditions, but may be placed approximately at 2 hp to 3 hp for the tilting, and from 6 hp to 9 hp for the duplex fixed hearth type.

Following are exact data on the operation of 12 tilting furnaces at the Great Boulder mine, Western Australia:

Ore contained 3.5 per cent sulphur; calcines contained 0.05 per cent.

Capacity of furnaces, 25 tons each in 24 hours.

Slope of hearth, 1 in. in 75 in.

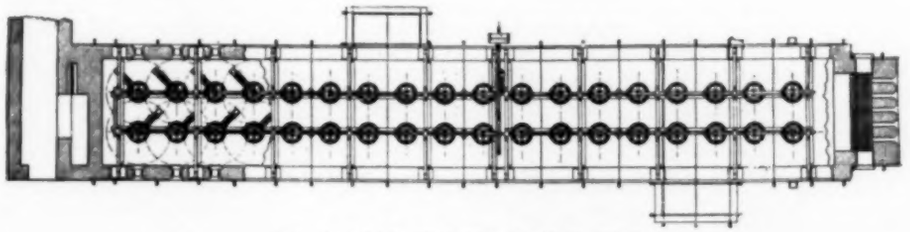


FIG. 4.—PLAN OF FIXED HEARTH TYPE.

Power required per furnace, 2 hp.

Fuel consumption, 9.2 per cent by weight of ore roasted.

Water required for rabbles, 400 gal. per furnace per hour.

Temperature of water raised 30 deg. in cooling process.

Data on other operations show a reduction of the sulphur content of various ores from 35 per cent to 0.285 per cent and 0.235 per cent. On sulpho-telluride ores such as Cripple Creek produces the furnaces installed at the Golden Cycle mill, Colorado Springs, Col., have a capacity of 100 tons per 24 hours, giving a sweet roast prior to cyanidation. The sulphur content of the ore is 2.5 per cent, and of the roasted product 0.08 per cent. The fuel consumption at this plant is 11 per cent, and the cost of roasting between 55 and 60 cents per ton.

These examples will serve to show the place which roasting

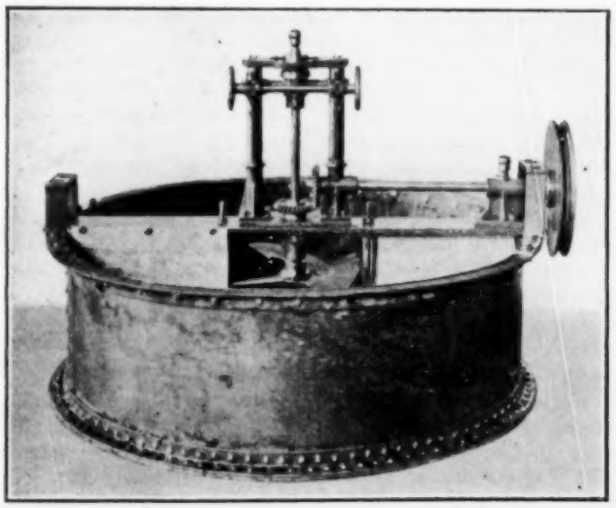


FIG. 5.—MODEL OF A. Z. AGITATOR.

is assuming in hydrometallurgy, where it is impossible to treat the ore chemically in its natural state.

Agitation.

After roasting the extraction of precious metal takes place in the A. Z. agitator. This device is simple in construction and can be applied to any circular tank. As shown in Fig. 5, which represents a small model, it consists essentially of a propeller placed centrally in the tank, with two deflector plates, one on each side of the propeller. The deflectors are fixed in position and extend almost to the bottom of the tank, while the propeller is adjustable up or down and when in operation revolves in a horizontal plane within a shallow cylinder open at both ends. The diameter of the propeller is usually about one third that of the tank.

The combination of propeller and deflector plates brings about an efficient agitation by setting up underlying centrifugal currents radiating from the bottom and center of the tank to all points of the tank wall, and overlying centripetal currents from the wall to the center. The deflectors prevent the entire mass from acquiring a swirling motion in the tank.

Fig. 6 illustrates a 20-ft. tank, of a capacity of 50 tons a day, in operation. The effect of the agitation is seen on the tank contents. The surface assumes a slightly concave form as the currents rising at the wall are constantly drawn downward toward the center of the tank. In the downward flow air is naturally drawn into the pulp and thor-

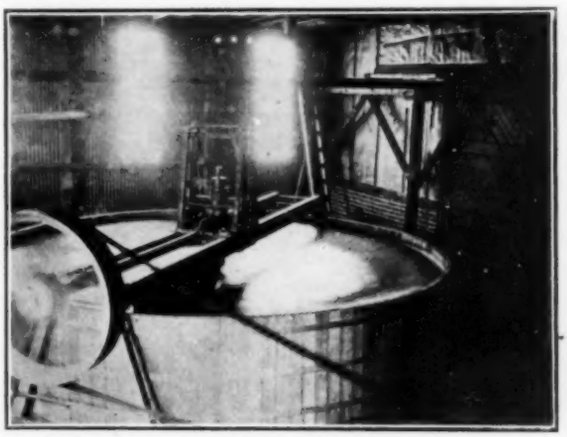


FIG. 6.—THE A. Z. AGITATOR IN OPERATION.

oughly mixed with it, and the evidence of thorough aeration is seen in the effervescence which occurs when the agitator is stopped.

The advantages claimed for the agitator are:

1. Saving of time in treatment.
2. Reduced consumption of cyanide.
3. Increased extraction.
4. Low power requirements.
5. Application to any existing round tanks.
6. Agitation of mixed sand and slime, eliminating classification.
7. Aeration without accessory air-compressing apparatus.
8. Rapid quiescence and settling of the pulp when the propeller is stopped.
9. Ease in restarting, even after long settlement of pulp.

Since its introduction in Australia the A. Z. agitator has been installed in all of the important metallurgical works in that field. It is used not only in the cyanide process, but also as a thorough mixer where uniform delivery and mixture of pulp are demanded, as in the De Bavay zinc separation process, and for concentration-table feed. In ordinary cyanide work it is found that the extraction is usually at its maximum in about four hours. Either sand, slime or a mixture of both may be treated, either roasted or raw, excellent extraction being obtained on some raw concentrates.

An example of the work done by this machine is found in the operations of the Waihi Grand Junction Gold Company, Waihi, N. Z. Table concentrate is cyanided raw in 20 ft. x 7 ft. A. Z. agitators, with a recovery of 92.3 per cent of the precious metal values, after 24 hours' agitation. The charge consists of 50 tons of concentrate and 46 tons of solution, the

total of 96 tons being agitated with 11 hp. The specific gravity of this concentrate is 4.5. Another example, from Western Australia, is found at the works of the Associated Gold Mines, where the time of agitation was reduced from 12 to 4 hours, or one-third the time formerly required with other methods. The improvement in recovery was as high as 4 per cent more than that obtained without these agitators.

In addition to its work in metallurgy, the A. Z. agitator is efficient in various branches of chemical engineering where thorough mixing, emulsifying, dissolving or evaporating is required.

Treating Antimonial Gold-Bearing Ores.

Not so long ago it was considered unlikely that the cyanide process would ever be used successfully in connection with the treatment of certain refractory ores. Recently this theory has been upset. Antimonial gold-bearing ores have always given trouble and have been avoided, but to-day these ores can be handled successfully, and the improvement in hydrometallurgy is responsible for the solution of the problem. A description of the Masson process (for which patents have been issued) may be found of interest. This process is in extensive use in the Wandong district, Victoria, Australia, and especially at the famous Golden Dyke antimony mine. The ore treated usually contains about 20 per cent antimony (stibnite) and from $10 to $12 gold per ton. The method of treatment is as follows:

The ore is ground to pass a 40-mesh screen and is then agitated in A. Z. agitators with hot solutions of caustic alkali. The agitation is so perfect that the antimony goes into solution very rapidly, usually in about two hours. The liquor containing the antimony is then separated from the ore, and run into precipitation tanks where the antimony is precipitated very rapidly as pure metal on sheets of aluminium. After the extraction of the antimony, if the ore contains a large percentage of sulphide of iron, it is roasted in Edwards furnaces before being subjected to agitation with weak KCN solution for the extraction of the gold contents. This second agitation also takes place in A. Z. agitators, and it is found that after roasting no trouble is experienced in obtaining high extraction of the precious metal, as high as 97 per cent of the gold being recovered.

The consumption of cyanide is very slight, in fact the average consumption at the Golden Dyke mill is 0.04 per cent KCN per ton of solution used. The cost of the whole treatment is approximately $3 per ton of ore treated.

Numerous experiments were made at Wandong to ascertain whether stibnite actually consumed cyanide or not, as it was generally believed that it was the cause of heavy consumption. The results of these experiments on an old accumulation of tailings clearly proved to the writers that raw native sulphide of antimony is not responsible for the heavy consumption of cyanide, as is generally believed, provided the ore has been properly prepared for treatment. The difficulty seemed to lie in the proper neutralization of the ore. When using the leaching method this was very noticeable and gave great trouble.

Lime was used as a neutralizing agent and after various trials it was found advisable to make up an alkaline liquor by dissolving as much of the lime as possible, and then leaching this solution through the tailings in the vats. Complicated reactions took place very rapidly, and it was found that as soon as the surface of the ore became neutral the alkaline solution following would dissolve a portion of the stibnite, which would, in turn, be precipitated as red sulphide with the generation of sulphureted hydrogen gas as soon as the solution reached the strongly acid portion of the ore. The consequence was that the charge would become full of red sulphides, which react most injuriously with cyanide.

Leaching methods were then abandoned and agitation with the A. Z. agitator was tried. The agitators were filled with water and started. The ore was then introduced, and when everything was in suspension the lime was added. This was a complete success, as the entire ore content came in contact with the alkaline solution at the same time. When it was seen that the solution was fast gaining in alkalinity, as the lime was added gradually, it was at once recognized that it could be brought to any desired point, care being taken not to exceed the neutral point. After the separation of this solution the ore was subjected to agitation with a 0.15 per cent KCN solution. The consumption of cyanide was only 0.03 per cent and the extraction of gold was 87.32 per cent after one and one-half hours' agitation. The average value of these tailings was $6 in gold and 7 per cent of antimony.

Besides these experiments many others were made to compare the efficiency of the A. Z. with that of other forms of agitators under the same conditions. These results are also of interest as all other forms failed to give the results sought. Some, while agitating the finer products, failed thoroughly to agitate the material of higher specific gravity. Again the aeration in the other devices was faulty, and this would, probably to a great extent, account for the great amount of time saved by the A. Z. over the other machines tried. The perfect aeration of the A. Z. is one of the most important of its many good qualifications, being largely responsible for the reduction in time and improvement in recovery mentioned before.

International Congress of Applied Chemistry, 1912.

As repeatedly mentioned in these columns, the eighth International Congress of Applied Chemistry will meet in 1912 in the United States in accordance with an invitation extended to it by the President of the United States and as provided for by joint resolution of the Sixtieth Congress.

The official delegates from the Government of the United States to the Seventh International Congress of Applied Chemistry, held in London in 1909, were designated by that body as members of the organizing committee of the 1912, or Eighth Congress, with power to add to their number.

These official delegates, numbering 13, added 30 new members to this organizing committee. This so augmented committee held a meeting on Aug. 26 in New York City and again enlarged its membership. This meeting was very harmonious and it was evident that everybody endeavored to organize the Congress on the broadest foundation of chemical democracy.

The honorary president of the congress will be Dr. Edward W. Morley, West Hartford, Conn.; the president, Dr. William H. Nichols, New York City. The secretary is Dr. Bernhard C. Hesse, 25 Broad Street, New York City.

The Congress will be held in the first half of September, 1912. The place of the opening meeting will be Washington, D. C., with all subsequent sessions of the congress and its various sections to be held in New York City. Thereafter as many other cities as practicable shall be visited by the congress.

Nothing else has so far been definitely decided upon. Several of the more urgent matters are to be decided at a meeting of the organizing committee, to be held on Oct. 8, 1910, in New York City.

The congress will have the following sections and subsections: 1, analytical chemistry; 2, inorganic chemistry; 3a, metallurgy and mining; 3b, explosives; 4, organic chemistry; 4a, colors; 4b, physiological chemistry and pharmacology; 5, industry and chemistry of sugar; 6a, starch industry; 6b, fermentation; 7, agricultural chemistry; 8a, hygiene; 8b, pharmaceutical chemistry; 8c, bromatology; 9, photochemistry; 10a, electrochemistry; 10b, physical chemistry; 11, law, political economy and legislation affecting the chemical industry.

While the above sections and subsections are now provided for, new subsections may be formed, and the following four have so far been proposed: chemotherapy, conservation, india rubber and plastics.

Standardization as a Phase in Engineering Evolution.

It may fall perchance to the lot of some engineer who may have attained to all the honors which his branch of the profession can accord to him, to sit down in the closing years of his life to write a comprehensive account of the evolution of engineering. Not, however, to write a mere text-book type of narrative such as those chapters of books on steam engineering which merely describe early inventions without describing the force which led to their development, and which fail to narrate succinctly the manner or reason of their subsequent supersession. There exists already a surplus of such engineering literature, incomplete historically, but affording material among which the philosophic historian may obtain information sadly needing philosophic codification and study. The engineer-historian-philosopher in his work of modification can certainly make some quotations from Mr. Herbert Spencer's works, which afford the best ground upon which such an amplification may be based.

Mr. Spencer's early years of engineering work enabled him, when using engineering analogies to illustrate points in his writings, to select examples peculiarly applicable to the case under discussion. In none of his writings is this more noticeable than in "First Principles," where he first enunciated a definition of evolution which has not been upset by the later developments of scientific and social progress. More striking even than the definition itself are the chapters showing that the various distinct stages of evolution are common to the human race in its function of government, language, food and clothing, as well as to the solar system, or to the strata of the earth itself, or to the arts of sculpture, painting, music or literature. It is, therefore, an entirely permissible matter when taking into account what place standardization really occupies in engineering history, to consider it in the light of his definition of evolution.

That definition, as many readers will remember, is that "evolution is an integration of matter and concomitant dissipation of motion, during which the matter passes from a relatively indefinite incoherent homogeneity to a relatively definite coherent heterogeneity, and during which the retained motion undergoes a parallel transformation."

The historian of engineering evolution will have to consider many forces, such as that of segregation due to a following of the line of least resistance. Mr. Spencer points out: "If, then, there be any locality which, either by its physical peculiarities or by peculiarities wrought on it during social evolution, is rendered a place where a certain kind of industrial action meets with less resistance than elsewhere. it follows from the law of direction of motion that those social units who have been molded to this kind of industrial action will be segregated by moving toward this place. If, for instance, the proximity of coal and iron mines to a navigable river gives to Glasgow an advantage in the building of iron ships—if the total labor required to produce a given vessel, and get its equivalent in food and clothing, is less there than elsewhere, there is caused a concentration of iron-ship builders in Glasgow, either by detention of the population born to iron-ship building or by immigration of those elsewhere engaged in it, or by both."

Or, the phenomena of integration which causes certain animals to hunt in packs, or integrations "which arise when, out of several places producing a particular commodity, one gaining more and more of the business, draws to it masters and workers, and leaves the other places to dwindle, as witness the growth of the Yorkshire cloth districts at the expense of those in the west of England; or the absorption by Staffordshire of the pottery manufacture, and the consequent decay of establishments at Derby and elsewhere. We have those more special integrations that arise within the same city, whence result the concentration of corn merchants about Mark Lane, of civil engineers in Great George Street, of bankers in the center of the city. Industrial integrations which consist, not in the approximation or fusion of parts, but in the establishment of centers of connection are shown in the bankers' clearing house and the railway clearing house. While of yet another species are those unions which bring into relation dispersed citizens who are occupied in like ways, as traders are brought by the Exchange, and as are professional men by institutes by those of civil engineers, architects, etc." * * *

"The progress from small and simple tools to complex and large machines is a progress in integration. Among what are classed as the mechanical powers the advance from the lever to the wheel-and-axle is an advance from a simple agent to an agent made up of several simple ones. On comparing the wheel-and-axle, or any of the mechanical appliances used in early times with those used now, we see that in each of our machines several of the primitive machines are united. A modern apparatus for spinning and weaving, for making stockings or lace, contains not simply a lever, an inclined plane, a screw, a wheel-and-axle joined together, but several of each—all made into a whole. Again, in early ages, when horse-power and man-power were alone employed, the motive agent was not bound up with the tool moved, but the two have now become in many cases joined together. The firebox and boiler of a locomotive are combined with the machinery which the steam works. A much more extensive integration is seen in every factory. Here numerous complicated machines are all connected by driving shafts with the same steam engine—all united with it into one vast apparatus."

Or, again, a universal economic tendency toward greater heterogeneity is caused by the increasing ties, inter-commercial, inter-scientific, which bring into closer and dependent relationship town and town, industry and industry, state and state, continent and continent.

The student of engineering evolution will find it a very complex matter to set out the whole historically by reason of the close interrelation of section and section. The advance of the steam engine is not merely a matter of increasing sizes and a striving after economy of production, but is dependent upon the development of larger factories and a demand for larger engines, as well as upon the toolmaker who provided the engineer with heavier lathes, no less than upon the boilermaker for boilers capable of giving high-pressure steam. Both engine maker and boiler maker alike owe their great advances to the metallurgist for cheaper, lighter, and stronger raw materials.

The advance of the steamship to the 20,000-ton and 30,000-ton liners of to-day has been an instance in which the ship builder, the engine maker and boiler maker, with their allies at the furnace and the foundry, have responded to the demands of altered commercial conditions. The progress of the dynamo from the days of Faraday's experiments in electromagnetic induction to the numberless dynamos and motors of to-day has been a progress acted upon by many diverse forces. While the progress may be traced in its logical scientific sequence through several contributing fields, such as those concerned with magnetic permeability or with insulation or conductivity, there must also be studied the influence of parallel forces which render these subordinate developments possible, and which provided successful commercial employment for what would otherwise have been as useful industrially as a Wimshurt machine would have been to Christopher Columbus.

The present movement in favor of standardization in engineering must logically date back to the days when palaeolithic man expressed a general tribal preference for an axe head of a certain average weight, and when he hewed his flint arrowheads to as nearly a common size as possible. His successor demands guns of an exact bore, while cartridges are not made on any haphazard principle as to size.

Standardization really reaches its highest development in connection with military affairs. The highly drilled and uniformed regiments, armed with weapons whose parts are inter-

changeable, has slowly evolved from the days when the warriors of nomadic tribes followed their chiefs into battle. As in warfare, and in its preparations, the best machines are those which are the most fully equipped for the duties likely to confront them, so in the commercial struggles being waged, or about to be waged, between firms in the same industry, or between country and country, the organizations most likely to succeed are those whose methods secure the widest range of activities with the greatest economy.

Standardization in engineering has been a factor from the days when iron founders started to store their patterns in order to furnish sets of castings the exact duplicates of one another; later the almost universal adoption of the Whitworth standard threads for bolts and nuts of moderate and large sizes secured universal adoption, because of the real demand for the interchangeability of bolts and nuts of equal diameters. Standardization, too, also became the rule in certain factories, and side by side with the disappearance of the old millwright or all-round craftsman came the introduction of specialist workers with specialized duties engaged in the manufacture of standard interchangeable parts for machines of special types.

Standardization to a certain degree has been of great importance in railway design, and while one may regret the result of the battle of the gages in the United Kingdom, the benefits resulting from the adoption of one standard gage are undoubted. So also a standard loading height above rail level because of bridges and tunnels. Although certain dimensions in regard to railway work have become the heritage of the railway engineer, a considerable elasticity yet remained. With the increase of loads and speeds has come the demand for heavier permanent way construction, a matter in regard to which finality, while not yet attained, has resulted in the distinct classification of standardized weights per yard, sections, tests, and a rigid chemical analysis pertaining to bull-headed rails, flat-bottomed rails and tramway rails.

The British Engineering Standards Committee has also standardized pipe flanges (thereby affording infinite relief to many mechanical engineers), screw and pipe threads, Portland cement, copper conductors, and dielectric thicknesses, telegraph material, tramway poles, trolley grooves, trolley wires, speeds, pressures and frequencies for electric motors and generators, and, above all, rolled sections for constructional iron and steel. Locomotives have also been standardized for use on the Government railways in India. Mention must also be made of incandescent lamps and boiler tubes, rolled sections for bridges, building construction, and ship building; tests for iron and steel materials used for ships and for their machinery; steel castings and forgings for marine work; tires, axles and springs; electric supply meters; copper and its alloys; railway rolling stock, underframes and cast-iron pipes, while electric tramways, electrical plant accessories and other matters are under consideration. This list does not cover the whole category of engineering work, but so much has sprung from the appointment by the council of the Institution of Civil Engineers, in January, 1901, of a committee to consider the advisability of standardizing rolled iron and steel sections that ultimately one may conceive the Engineering Standards Committee with its definite tests as the supreme court of jurisdiction in regard to all engineering work, covering dimensions of component items, their composition and their physical properties.

Such a body will naturally be confronted time and again with the question to standardize or not to standardize. The history of every branch of engineering is a history of rival types and rival methods. In the competition between these, before the unsuitable went to the scrap heap, the successful types underwent several changes, increasing in complexity and acquiring a larger adaptiveness. When pre-eminence is secured for any particular practice, then comes the time for standardization. Among present problems of this nature may be said to be that of electric traction.

The need for standardization upon electric railways was urged by Mr. James Swinburne and Mr. W. R. Cooper in a joint paper read by them before the Institution of Electrical Engineers in 1902. In the discussion of the paper the present writer urged that at that time it was premature to talk about standardization of pressures or other electrical conditions so long as the gage and height above rail level were preserved, and so long as electric locomotives were employed. Interchanges between system and system could be effected by changing locomotives at junctions. At the present day direct-current, 500-volt systems have the longest mileage in England. The details as to the position of the conductor rails vary on different systems. There is, however, a keen fight ahead between direct-current and single-phase alternating-current systems, with the great probability that the latter system will be adopted in cases where both the suburban and main line systems will require electrification.

The above instance has its parallel in a number of other cases. The only moral to be drawn would be that the standardization should not be too rigid, and that the various committees and subcommittees should be always ready to revise existing standards, scrapping types which are obsolete as ruthlessly as they would scrap a bolt from which the thread has been stripped, and always ready to advise the introduction of new standards accordingly as the condition of the industry demanded. In short, the industry demands the same foresight and the same qualities of shrewd judgment from the supreme authority that characterize the administration of a large commercial firm.

Without this elasticity, standardization can only be the forerunner of stagnation, and perhaps of dissolution. Sharpness of definition "growing both greater and more variously exemplified as societies advance to maturity, is extremest in those which have reached their full development or are declining." Ultimately "decay follows a fixity which admits of no adaptation to new conditions."

Standardization may be said to mark that point in engineering evolution when the indefinite incoherent homogeneity has become merged into the definite coherent heterogeneity and a sectional condition of equilibrium more or less constant results. This process of equilibration tends ever to a greater completeness. "During early stages of social evolution, while the resources of the locality inhabited are unexplored and the arts of production undeveloped, there is never anything more than a temporary and partial balancing of such action. But when a society approaches the maturity of that type on which it is organized, the various industrial activities settle down into a comparatively constant state. Moreover, advance in organization, as well as advance in growth, is conducive to a better equilibrium of industrial functions. While the diffusion of mercantile information is slow and the means of transport deficient, the adjustment of supply to demand is very imperfect. Great overproduction of a commodity is followed by a great underproduction, and there results a rhythm having extremes that depart widely from the mean state in which demand and supply are equilibrated.

"But when good roads are made and there is a rapid diffusion of printed or written intelligence, and still more when railways and telegraphs come into existence—when the periodical fairs of early days grow into weekly markets, and these into daily markets, there is gradually produced a better balance of production and consumption; the rapid oscillations of the price within narrow limits on either side of a comparatively uniform mean indicate a near approach to equilibrium. Evidently this industrial progress has for its limit that which Mr. Mill has called 'the stationary state.' When population shall have become dense over all habitable parts of the globe; when the resources of every region have been fully explored, and when the productive arts admit of no further improvements there must result an almost complete balance, both between the fertility and mortality in each society and between its producing and consuming activities. Each society will exhibit only minor deviations from its average number, and the rhythm of its in-

dustrial function will go on from day to day and year to year with comparatively insignificant perturbations."

Before the sectional equilibrium is merged into universal equilibrium, many ages must elapse, while yet longer periods will intervene before the ultimate dissolution, which is a matter for philosophic speculation, will confront our descendants. So far as standardization is concerned, we are only on the threshold of a great effort to give uniformity and efficiency to manufacturing conditions. Its happening has been as inevitable as the evolution of the law of the civilized state from the traditionary rules of uncivilized communities. The standardized uniformity of the future must maintain a certain flexibility, or else it will be swept away by the pent up forces of a delayed progress.

But of this there seems little fear. The Anglo-Saxon race has always been eminently individualistic, and so long as standardization does not involve the suppression of the improvements which the individual thinker or individual manufacturer offers to the community, standarization will merely mean law and order in engineering design and installation, but law and order subject to further evolution and continuous modification. Nationally, the immediate advantage of standardization is great, for improved commercial efficiency has already been attained.

While there is a faint danger element that standardization may delay progress, just as the inertia of established industries tends to preclude a change in our systems of weights and measures for all save absolutely new branches of industry, the action of the committee in having revised certain details in their original standard specifications for Whitworth standard threads, Portland cement, and of ingot steel forgings, copper conductors, and material used in the construction of railway rolling stock is more than fair proof that this spirit of *laissez-faire* is not to be dreaded.

When in addition to this it is remembered that a report was issued in 1905 on the "effect of temperature on insulating materials" it will be fully recognized that such an administrative body has great potentialities in the incitement of the technical and scientific research and progress of the Empire whose evolution from "the relatively indefinite incoherent homogeneity to a relatively definite coherent homogeneity" calls to-day for constructive's statecraft of the highest order.

London, England. TURRIS.

Notes on Chemistry and Metallurgy in Great Britain.

(From Our Special Correspondent.)

The Manufacture of Cyanamide in France.

The production of cyanamide has been started by the Société Commerciale de Carbure et de Produits Chimiques near Notre Dame de Briançon. The works are adjacent to the Metal Carbide Company's factory, whence the supply of carbide is conveniently obtained; and current is supplied from the Carbide Company's power house, about 11 km distant, at 15,000 volts, three-phase, 42 cycles. The nitrogen is furnished by the Linde method from air freed from carbon dioxide and moisture, with Burckhardt compressors operating in three stages. Carbide is received in large masses, which are broken up by stamps and powdered in a ball mill. The furnaces, of which there are 30, have a capacity of 300 kg each, and the present output of cyanamide is about 10 tons per day, which amount is capable of being doubled with the space and power now available.

Electrical Smelting of Iron Ore.

A British consular report from Stockholm states that the Swedish installation for electrical smelting at Trollhattän is progressing satisfactorily, and that experimental work with the old furnace at Donnarfvet is again going on. As a consequence, it has been officially announced that the results are superior to those from earlier efforts, and the superintendent is of opinion that a definite solution of the problem of replacing the blast furnace by electrical smelting has been worked out.

From a report of the British Legation at Christiania it appears that an experimental furnace at Tinnfos is turning out iron at a cost of £3 per ton practically equal in quality to best Swedish charcoal iron which costs £5 to £5 10s. per ton. At present the output is only three tons per day, but it is proposed to increase the power to 100 hp and turn out 25 tons per day, and also to proceed with the production of steel, at an estimated cost of £4 10s. per ton as against about £10 per ton for charcoal steel of the same grade.

Portland Cement.

The British standard specification for Portland cement has again been revised by the Engineering Standards Committee. The outcome of the committee's inquiry as to the determination of the time of initial setting was that a discrepancy was found between the results obtained with the British standard needle and those with the Vicat needle, although the times of final setting agreed fairly closely. It was considered advisable that the specification should direct the use of only one instrument for determining both the initial and final times of setting; and, as the Vicat needle is pretty generally used, the committee decided to adopt it. With regard to soundness tests, the question of providing against expansion of the cement in cold water was negatived, as the investigations showed that results of tests of the plunging order depended on the time of setting more than on the soundness. As to chemical composition, a *minimum* for total lime has been laid down as a provision against the admission of cements which are not "Portland." The loss on ignition and the total sulphur (sulphides as well as sulphates) have also had their limits specified. The directions for gaging in paragraph 6 of the first revision were not very precise; and these have been altered to the extent of defining the requisite consistency of the gaged cement. The increase of tensile strength of briquettes of mixed cement and sand for longer periods than seven days is now more explicitly stated in the same way as that for neat briquettes.

Unless the 1/16-in. square needle weighted to 2½ lb. had points of superiority over the Vicat needle in determining the time of final setting it may safely be assumed that the former would never have been specified by the committee; and the reasons now given for discarding an instrument which the Standards Committee had selected as the most suitable will hardly commend the change to the large section of practical cement users to whom the time of initial setting is a negligible quantity compared with the time for complete setting. The B. E. S. needle would give determinations of the initial setting time quite as consistently as the Vicat; and determinations of this ill-defined point by different operators with either instrument might vary as widely as the results with both.

Researches published early in 1909 on the influence of sulphates on the deterioration of cement work indicated that sulphates exercised a much more deleterious effect than was commonly recognized, especially in submerged work; and the existing limit for sulphuric anhydride might be materially reduced with advantage.

The British Association.

The program for the forthcoming meeting at Sheffield includes the following papers: *Section A* (Mathematical and Physical Science)—"Atmospheric Electricity," by Dr. C. Chree; report of Gaseous Explosions Committee. *Section B* (Chemistry)—"A Fourth Recalescence in Steel," by Professor Arnold; "Influence of Chemical Composition and Thermal Treatment on the Properties of Steels," by Prof. A. McWilliam; "Ferrosilicon," by Dr. S. Monekton Copeman; "Corrosion of Iron and Steel," by Dr. J. N. Friend; "Crystalline Structure of Iron at High Temperatures," by Dr. Rosenhain; "Allotropy of Trans-

mutation?" by Professor Howe. *Section G* (Engineering)—"The Testing of Lathe Tool Steels," by Professor Ripper; "Optical Determination of Stress," by Professor Coker; "Heat Insulation," by F. Bacon; and report of the Gaseous Explosion Committee, joint discussion with Chemical Section.

The Mallet-Boulouvard Ammonia Soda Process.

This process as carried on by the Compagnie Générale des Produits du Midi at Sorgues has been described in detail and somewhat adversely criticized by M. K. W. Jurisch, who states that while the estimated daily production is actually reached, an increased output cannot be attained when required to the same extent as in other methods. The system of filtration was good but expensive. The cost of calcination was too high, and another calcination process would be preferable. The factory cost a million francs and the production is 10,500 kg of sodium carbonate per day. A Solvay plant to turn out 20,000 kg to 25,000 kg per day could be added for 250,000 francs.

Market Report.

AUGUST, 1910.

Copper rose to £55.10.0 on the 3d, touched £56.7.6 on the 17th, then dropped to £55.8.9 and at the end of the month is firm at £55.15.0.

Tin mounted steadily from £151 on the 3d to £154.12.6 on the 17th and after a slight decline in the following week was bulled to £163 on the 31st.

English lead participated to a slight extent in the general improvement during the first week, but has since remained steady at £12.17.6.

Iron, Hematite, after easing to 64/- recovered to 65/3 on the 24th and remains at that figure.

Scotch Pig, with a better inquiry, went up to 56/- at mid-month, but has declined gradually to 55/6½.

Cleveland Warrants have been firmer, and reached 50/- on the 17th, but have declined again to 49/5.

Alum, lump, loose, per ton	£5.12. 6.
Antimony, black sulphide, powder, per ton	24. 0. 0.
Borax, British refined Xtl, per ton	16. 0. 0.
Sulphate of ammonia, per ton	11.16. 3.
Sal ammoniac, firsts, delivered U. K., per ton	42. 0. 0.
Copper sulphate, per ton	18.12. 6.
Caustic soda, ash, 48 per cent, ordinary, per ton	5.10. 0.
Bleaching power, 35 per cent, per ton	4. 5. 0.
Sulphur, per ton	5. 0. 0.
Litharge, flake, per ton	15. 0. 0.
Red lead, genuine, per ton	15.10. 0.
Shellac, T. N. orange, spot, per cwt	4. 4. 0.
Hydrochloric acid, per cwt	5. 0.
Copper ore, 10 to 25 per cent, per unit	9/- to 10. 0.
Tin ore, per ton	£95-97. 0. 0.
Carbolic Acid, liquid, 97 to 99 per cent per gal.	11½.
Creosote, ordinary, good. liquid, per gal.	2⅛.
Naptha, solvent, 90 per cent at 160 deg. C., per gal.	1. 1.
Camphor, 1-oz. tablets	1. 7.
Mica, small slab, original cases, per lb	6d. to 1. 0.
Platinum, per oz	6.15. 0.

India rubber declined to 8/- on the 10th; recovered to 9/7 on the 17th, and has steadily fallen to 7/11 on the 31st.

London, August, 1910.

Synopsis of Metallurgical and Chemical Literature

Gold and Silver.

A Comparison of Slime Treatement Methods, filter pressing compared with decantation and the Adair-Usher process, is outlined in the April, 1910, issue of the *Journal* of the Chemical, Metallurgical and Mining Society of South Africa, by John D. O'Hara. The author took charge of a plant at which filter presses had been installed for the treatment of accumulated slime. The system of treatment included the agitation of the slime with neutralizing agents, after which it was run by gravity to a Montejus, whence it was sent to the presses by compressed air. Here it was washed with the requisite cyanide solutions and final water wash, after which air was blown through the presses to dry the cake before discharging. This treatment was successful, but the working cost was too high. The average extraction from residues of irregular value was 88 per cent. The solution obtained from the presses was not clear enough to go at once to the precipitating boxes and had to be filtered in large vats. The causes of failure of the press plant are given as: 1. Cost of filter cloths. 2. Heavy consumption of cyanide and lime. 3. Cost of handling slime from dam to dump. 4. Small capacity of the presses, three in number, the usual quantity handled being 48 tons to 56 tons per 24 hours.

Decantation was then tried and the slime was pumped from the decantation plant to the agitators and thence to the filter presses, with the idea of recovering the gold in solution and reducing the quantity of undissolved gold. But this did not pay the cost of handling, and it was cheaper to discharge the slime to the dam and pump back the solution. Then the experiment was tried of using the presses to clarify the solution decanted from the slime and this proved successful and profitable. The extraction gained was 85.7 per cent.

Later the Adair-Usher process was installed, with the result that the extraction was improved, at the beginning amounting to 87.6 per cent and later rising to 90.3 per cent. The author regards the Adair-Usher process as an effective means of washing slime and displacing the gold solution. Waste steam is used at this plant for heating the slime solutions, especially in the winter, as the heating is found to aid quick settling.

Copper.

Data on Copper Converting in Australian smelters are contributed to the *Australian Mining Standard* of June 1 and 8, 1910, by Mr. H. Schroder. The largest converters in use are 10 ft. 6 in. by 7 ft. 6 in. With these vessels one ton of blister copper can be produced per hour from 45 per cent matte, blowing only one vessel at a time, with 3000 cu. ft. of air per minute at a pressure of 9 lb. per square inch. With 35 per cent matte the blister is reduced to 0.75 ton per hour. The supply of air should preferably be 4500 cu. ft. per minute at a pressure of 10 lb. to 12 lb. per square inch. The large converters take an initial charge of 6 tons of matte, and a charge of 10 tons to 12 tons on the sixth, seventh and following blows. With 45 per cent matte they can average 27 tons of blister per converter. The best run known to the author was 36 tons of blister, the converter handling 11 charges before relining. The data on a month's run, with one converter in blow at a time, are as follows: Average blows per converter, 8.4; average blister per converter, 27 tons: blister per hour, 1.17 tons; blister copper produced, 216.6 tons; matte treated, 460 tons, together with 6 tons copper refinery slag and 25 tons white metal.

Grade of Matte.—The author finds the most suitable grade of matte to be 45 to 48 per cent coppèr, although higher grades, such as 65 to 70 per cent matte, may be converted successfully if alternated with the 45 per cent grade. The worst grade of matte to deal with is 55 per cent copper, as it does not form enough slag to skim properly, and yet there was too much to skim with a rabble, the slag granulating and forming an un-

desirable product. The average copper produced from 46 per cent matte was 1.17 tons per hour; from 66 to 70 per cent matte, 1.8 tons per hour.

Converter Lining.—Three mixtures are used for tuyeres, body and cover. For tuyeres, 68.5 to 70 per cent SiO_2; for body, 80 to 82 per cent SiO_2. The lining mixtures are made up of silicious material, clay and old lining. Following are the quantities used:

	Silicious Ore.	Clay.	Old Lining.
Patching mixture	1	1	..
Cover mixture	1	1	2
Body mixture	5 to 8	1	1
Tuyere mixture	2 to 3	1	..

If clean, old lining can be used alone for cover mixture, and it is advisable to use as much old lining as possible throughout the converter. As high as 6 parts of old lining, 5 of silicious ore and 1 of clay has been used, but such linings do not suffice for the production of more than 16 tons of blister. The author states that the method of lining has a great deal to do with the way in which a converter stands up to its work, and that within certain limits of silicon content the method of lining the converter is more important than the chemical composition. The ramming must be carefully done, the back or tuyere side being brought up straight to the throat, and the front only being tapered to the throat, which is finished to a diameter of about 2 ft. The converter is dried out with a wood and coke fire for 20 to 30 hours, and is at a dull red heat when it is put in use.

Blowing.—No fixed rules can be laid down regarding the slagging and finishing points of the blow. Mattes of different composition give different flame colorations, varying from heliotrope to green when the slagging point is reached. The finishing points are even more varied than the slagging points, but the color at slagging points can be depended upon when using the same matte. The author describes in detail the various changes that can be expected in the course of the blow to slag and to copper, including the phenomenon noticed when the charge is overblown or burnt.

The cost of converting 45 per cent copper matte in the large vessels described, producing 1 ton of blister per hour, one vessel only being in operation at a time, is given as follows: Cost of power, 1.1 cent (0.55d.) per kw-hour; silicious material, $1.50 (6s.) per ton; fireclay, $3 (12s.) per ton; retreatment charges, 37 cents (1s. 6d.) per ton for slag, and $2.50 (10s.) per ton for old lining. On this basis the converting costs $4.58 (18s. 4d.) per ton of blister produced; relining, $2.97 (11s. 11d.); retreatment charges, 87 cents (3s. 6d), or a total of $8.42 (£1 13s. 9d.) per ton of blister produced. In the smaller converters the cost is from $2.50 to $3 per ton more. If the grade of the matte is but 35 per cent copper the cost in the large converters is $11.45 per ton of blister. If copper is produced in reverberatory furnaces, the cost is about $17.31 per ton and the product contains but 97 per cent copper as compare with 98.5 per cent copper in the blister produced from the converter.

Zinc.

The Chemical Treatment of Zinc Ores with the sulphurous acid evolved in the roasting of the same is reported to be in successful operation at Swansea, according to the *Mining Journal* (London) of July 16, 1910. In our current review of metallurgical patents will be found the specifications of the United States patent granted on this process. The ore is roasted, leached in a sulphurous acid solution, forming bisulphite of zinc, which is precipitated by passing steam through the solution, driving out the excess of SO_2. The precipitated sulphite of zinc is then roasted to zinc oxide. When a complex sulphide is treated the products are: (1) Zinc oxide practically free from lead; (2) the filtered residues carrying lead and any of the precious metals that may have been in the ore; (3) sulphurous acid which has been put in excellent condition for the manufacture of sulphuric acid. It is reported that a large tonnage of zinc-lead ore has been treated by this process with a recovery of 89 per cent of the zinc content. Cost is reported to be 75 cents (3s.) per ton, but the conditions are not given.

Tin.

Tin Dressing in Tasmania at the Mount Bischoff mine is described in detail by J. D. MILLEN in the *Mining Journal* (London) in the issues for Aug. 13 and 27. The ore treated has an average tin value of 0.54 per cent Sn. It is first crushed in stamps weighing 562 lb. each. The dies wear at the rate of about ½ in. per month for a duty of 150 tons. The shoes wear at the rate of 1.2 oz. per ton of ore treated. The stamps drop 88 times per minute through a height of 8 in., and have a duty of 7.5 tons each per 24 hours. After stamping the pulp is classified in hydraulic spitzlutten, of which there is a pair to each 10 head of stamps. The overflow goes to settling spitzkasten and the spigot discharges to coarse and fine jigs. The jigs are of the Harz type and make finished hutch products. The jig for coarse material has 200 pulsations per minute and a stroke of 5/16 in. The fine jig has 250 pulsations and a stroke of 3/16 in. The former handle 10 tons per day and the latter 13 tons. The jig tailings are conveyed to classifiers and thence to Card and Wilfley tables.

The overflow from the first spitzlutten mentioned above is settled as described and the finer sand is treated on Luhrig vanners and round tables, and the coarser sand on Card and Wilfley tables. The round tables are 16 ft. in diameter and have a slope of 5.5 degrees. They make one revolution in two minutes. The Card and Wilfley tables have a feed from the tailing of the jigs, the coarse sand from the spitzkasten and the middling from the round tables. The fine jigs followed by the Card tables make a recovery of 86.7 per cent of the total tin content drawn from the No. 2 spigot of the spitzlutten. The Wilfley tables and the fine jigs make a recovery of 86.06 per cent Sn.

The Luhrig vanners are of the duplex type; slope, 4.5 degrees; 150 bumps per minute; belt travel, 6 ft. per minute. They receive a product which all — 100 mesh and handle about 18 tons per day on both belts. The pulp fed assays 0.56 per cent Sn, and the tailing assays 0.03 per cent Sn. The middling from the vanners is treated on Sperry vanning tables. These tables are adjusted to have a circular vanning motion of 200 throws per minute, 0.3 in. in length; revolution of the table is once in 1.25 minutes; slope, 5.5 degrees.

The slime plant consists of rotary and Crad tables, and the procedure here is practically the same as described for the initial treatment. A new stamp mill of 10 heads of 1050 lb. each has been placed in operation recently, with an accessory equipment consisting of revolving screens, grinding pans and Card tables.

Grading.

Grading Analyses and Their Application.—The determination of the relative merits of different crushing appliances from grading analyses of their crushed products has been receiving considerable attention of late, particularly in connection with the controversy over the introduction of the heavy-stamp tube-mill combination in South Africa. In the May, 1910, issue of the *Journal* of the Chemical, Metallurgical and Mining Society of South Africa, Mr. H. STADLER proposes a new system of grading crushed products, based on the reduction of the volume (or weight) of the particles. The sizes of the author's proposed grading scale are in close agreement with certain of the standards established by the Institution of Mining and Metallurgy. On nine grades, from 1-in. mesh down to 30 mesh, the true average weight of the particles of each grade has been ascertained, and the ratio of decrease in weight of these particles proved to correspond remarkably well with the correct reduction scale of theoretical cubes. The relation

of the true average size of the particles to the corresponding theoretical cubes representing the mean grade between the grades of the screens varies in nine tests between 58.3 and 66.9 per cent, and the average of 61.4 per cent can, therefore, be considered fairly representative for Rand ore and for a product coming from breakers.

The author claims for his system of standardization of grades the following advantages:

1. No really new departure from standard practice.
2. Equality of steps with regard to reduction in volume.
3. A sufficient number of grades.
4. Independence of wire gage, and, therefore, immediate applicability to screens of any description with round or square holes.
5. The standard *grades* are exactly the same for screens in practical use in metallurgical operations as for laboratory purposes, while the *screens* may vary in accordance with the gage of the wire used, with degree of accuracy in their manufacture.
6. No limit to extension in either direction or by interpolation.
7. The variation of all other functions of the particles, besides diameter, can be expressed by equations or plotted in regular curves.
8. Any odd screen of which the clear aperture is known can readily be inserted in the scale by use of a formula deduced by the author.
9. The ordinal numbers represent at the same time the relative value of the energy required to produce the respective grade from the unit.
10. The average values of screen products determined by possibly far distant screens are readily obtained.
11. Any projected standardization of battery screens can easily be made to fall in with the present scale.
12. The so-called 60-mesh and 90-mesh screens (aperture 0.01 in. and 0.006 in. respectively) are already in general use on the Rand.

The author presents the theory of the application of grading analyses to the calculation of the relative mechanical efficiency of crushing machines, and gives two examples of calculations for the stamp and tube mill. He concludes that we are now in a position to determine with a comparatively high degree of accuracy the relative merits of different crushing appliances, or the mechanical efficiency of one and the same machine working under varying conditions.

Chemical Engineering.

Fuming Sulphuric Acid.—The old method of testing the strength of fuming sulphuric acid by titrating with a normal alkali solution is not considered satisfactory for technical use by Mr. Henry Howard, who has presented to the Society of Chemical Industry the details of a new method. The principle involved is the measurement of the heat developed by combining the free sulphuric anhydride with water. As this heat value is very great, a small variation of the percentage of anhydride makes large variations in the heat produced. To eliminate the heat of dilution of sulphuric acid, the author uses sulphuric acid of certain concentration instead of water with which to mix the fuming acid. When a 20 per cent to 25 per cent fuming acid is to be tested he uses a sulphuric acid of 92 per cent H_2SO_4 as his source of water. A Dewar vacuum tube is used for the work.

One hundred grams of the fuming acid to be tested are weighed into a Dewar tube. The temperature (a) is noted, and then temperature of the reagent acid, after which 100 g. of the 92 per cent acid are poured into the Dewar tube and mixed with the fuming acid. The temperature (c) of the mixture is recorded. The heat of reaction equals $C = \frac{a+b}{2}$, making no allowance for the heat capacity of the tube. In order to avoid corrections for this or other slight errors, tests are made in this manner with fuming acids of known composition, and from these results the following table is compiled:

Temp. deg. F	Free SO_3.	Temp. deg. F.	Free SO_3.
72.0	21.0	87.6	23.6
73.2	21.2	88.8	23.8
74.4	21.4	90.0	24.0
75.6	21.6	91.2	24.2
76.8	21.8	92.4	24.4
78.0	22.0	93.6	24.6
79.2	22.2	94.8	24.8
80.4	22.4	96.0	25.0
81.6	22.6	97.2	25.2
82.8	22.8	98.4	25.4
84.0	23.0	99.6	25.6
85.2	23.2	100.8	25.8
86.4	23.4	102.0	26.0

The table shows a difference of 6° Fahr. for each per cent increase in anhydride, and as the readings can be depended upon to within ½° Fahr., the results obtained are extremely accurate.

The same principle can be applied to the determination of the strength of ordinary sulphuric acid between 95 per cent and 100 per cent. The reagent used is fuming sulphuric acid and it is used in excess, so that the heat generated represents the uncombined water in the regular sulphuric acid. The same formula applies.

Sulphate of Ammonia.—The precedure at the Dumfries Gas Works (Scotland) was outlined in a paper read before the Western District Division of the Scottish Junior Gas Association, at Glasgow, by Mr. J. H. Smith. After describing the plant for the manufacture of ammonium sulphate, the author gave the following résumé of costs:

	Per ton of salt.
Acid and oil, 1700 lb.	$7.43
Lime, 170 lb.	.30
Wages	3.52
Cartage	.14
Steam and water	.75
Liquor, 11 tons, 1630 lb., 2.1 per cent.	24.37
Interest on loan at 3¾ per cent.	2.85
Depreciation	3.25
License	.11
	$42.72

The average price of the salt for the year 1908-9 was $53.03. The sulphate produced per ton of coal was 25.5 lb.

Suction Gas Plants are increasing in use in every part of the world, and are apparently finding favor with power users. In western Australia there are several types of producers and engines in use at mines, mills and industrial plants of every description. In the July 30 1910 issue of the *Mining Journal* (London), Mr. M. von Bernewitz gives some details regarding these plants, having secured his data from personal inspection. Charcoal is the fuel generally used, as the coal available produces too much tar, and apparently the tarless producer has not been developed there as it has in the United States. Both steam and electricity have been superseded by gas in many instances; two cases where steam was abandoned in favor of gas showed savings of $350 to $400 per month in fuel alone. The average consumption of charcoal per b.h.p. is 1 lb., while for coal (when used) it is 1 lb. to 1½ lb. Most of the plants are small, i.e., under 150 hp. Most of the engines are built with two heavy flywheels, with the driving pulley on one side overhanging. The author regards this as a mistake in construction, and found many managers of plants to agree with him. There should be an outside bearing to relieve the crankshaft. The author found it difficult to arrive at definite costs, but believes that 2 cents (1 d) per b.h.p. may be said to be a fair average cost.

Following are some data on actual installations: A 104-hp mill plant, using about 86 hp, fuel consumption per hp-hour, 0.9 lb.; cost per hp-hour, 1.488 cents (0.744 d.). Another plant using 70 hp showed a cost of 1.64 cents (0.82 d.) per hp-hour. This was favorable as compared with 5 cents when electricity was used. At still another milling plant the comparative costs for steam and gas power were $550 and $100 per month, respectively. Other data are given on various kinds of plants.

Recent Metallurgical and Chemical Patents

Iron and Steel.

Manganese Steel.—A manganese steel ingot, devoid of dendrites and other objectionable freezing structures and of a strong uniform fine-grained structure throughout, for rolling and forging, is produced by a combination of chemical and heat treatment devised by Mr. WINFIELD S. POTTER, of New York City. The first step is chemical and consists in the preliminary deoxidation and cleansing of the metal. The manganese steel is compounded from dephosphorized and desulphurized molten steel from an open-hearth or other furnace and molten ferro-manganese, mixed in a casting ladle of large capacity, say 60 tons or more. The ladle is acid-lined and a layer of acid slag (produced from silicious material and fluxes, like sodium silicate, lime or lead oxide) protects the metal in the ladle from surface oxidation. The proportion of silica should be slightly more than sufficient to balance the oxides in the steel plus the small amount of basic furnace slag which may have come into the ladle. The acid-slag-making materials are charged into the ladle either before or during the charging of the molten steel in order to obtain such an intimate contact of the acid slag formed and the metal as to insure the washing out of oxides from the steel. The metal in the ladle contains about 12 per cent manganese and from 0.8 per cent to 1.1 per cent carbon. The temperature of the metal in the ladle during the cleansing operation is from 1400 deg. C. to 1450 deg. C. The metal, with its protecting acid-slag layer, is permitted to rest in the ladle long enough to insure separation of slag and metal and to cool to about 1375 deg. C., when it is poured through a bottom pouring aperture. While the ingot is still in the mold it is cooled in such a manner that when stripped from the mold the outer portions (to a depth fully including the thickness of the zone of the dendrites) will have an average temperature in the neighborhood of 1000 deg. C. (say from 950 deg. C. to 1050 deg. C.) except at the edges, where it will be unavoidable considerably lower. This enables it to be transferred without suffering any rupture into a soaking pit, where it is to be subjected to the heat treatment designed for reconstructing its exterior portions; and it also permits this heat treatment to take place without cracking the ingot. At the time of its entrance into the soaking pit the ingot has set and developed its freezing structures to a depth of, say, 6 in. or more inwardly from its outer skin or periphery and a zone of dendrites has formed which usually occupies, say, about one-half of this depth. In order to break down these dendrites and to substitute therefor a strong uniform structure of fine grain the temperature of the soaking pit is slowly raised to 1175 deg. C. or a somewhat higher temperature, this being effected in a smoky or reducing atmosphere, so that the periphery of the ingot will not be oxidized. This requires a comparatively short period of time, say half an hour. This stage of the heat treatment is then arrested by lowering the temperature so as to prevent the building up within the mass of larger and coarser grains. To this end the temperature prevailing within the soaking pit or other heating furnace may be lowered by the injection of water vapor, in the form of a steam jet carrying with it water in suspension, with the result that the periphery of the ingot is reduced in temperature to, say, 1100 deg. C.; or for the same purpose the ingot may be cooled by transferring it into a cooler soaking pit. The lowering of the temperature of the exterior portions of the ingot is accompanied with the formation of a tough skin, which shrinks upon and works the still plastic interior. Finally, after the cooling of the outer portions of the ingot has occurred and the steam jet has been cut off the outer portions of the ingot are permitted to rise again in temperature to, say, 1125 deg. C., in order to equalize the surface temperatures and to obtain the desirable maximum ductility, whereupon the ingot may be removed from the soaking pit and is in condition to be immediately rolled into rails or other products in mills of ordinary construction. Moreover, the temperature conditions are such that a track rail, for instance, of standard length and section, rolled from such an ingot will be delivered from the final pass of the rolls at a temperature which will permit it to be toughened by quenching without being first subjected to a reheating operation. The cooling temperature of 1100 deg. C. and the reheating temperature of 1125 deg. C. are suitable for manganese steel containing 1.10 per cent carbon or less. When the carbon is higher, say 1.20 per cent or more, somewhat lower cooling and reheating temperatures are employed.

The process can be changed in its later stages, as an alternative way of toughening the outer portions of the ingot is available instead of subjecting it to cooling in the soaking pit. The ingot may be taken from the soaking pit, in which it has been slowly and evenly heated to a temperature of from 1175 deg. C. to 1225 deg. C., depending upon the analysis of the metal, and is then subjected to light mechanical working over its periphery for the purpose of producing a wrought thick skin thereon. The lower temperature (1175 deg. C. or thereabout) is preferred when the amount of carbon present in the ingot is above 1.20 per cent; and the higher temperature (1225 deg. C. or thereabout) is preferred when the amount of carbon present is 1.10 per cent or less, it being assumed in both of these instances that any phosphorus present is low in amount. Let us assume that the manganese steel ingot is a 20-in. x 20-in. square section. The light preliminary rolling would then be effected by acting first simultaneously upon two horizontal sides and then turning the ingot and acting simultaneously upon the two remaining sides. Where the analysis of the manganese steel of the ingot shows it to be low in carbon (say, containing 1.10 per cent of carbon, or somewhat less than that amount), the reduction in the first one or two passes of the preliminary light rolling may be about 1 in. in each pass. This first reduction along the two horizontal sides of the ingot renders the metal of those sides capable of greater elongation, and consequently when the ingot is turned over and rolled along its opposite sides, a somewhat greater reduction can take place, say 1½ in. or 1¾ in. These two preliminary reducing passes will in general suffice for the light preliminary rolling intended. When the manganese steel has a harder analysis, i. e., when the percentage of carbon is as high as 1.20 per cent or higher, it will usually be advisable to limit the first reductions of the series of light preliminary passes to from ½ in. to ¾ in. This welding or consolidating of the outer portions of wrought skin or steel is of particular importance where the reduction contemplated in the rolling mill is considerable for the initial passes. It is carried out quickly, so that there may be no material drop in temperature and the ingot is then delivered to the rolling mill and rapidly reduced in the usual manner. (968,601, Aug. 30, 1910.)

Alloy Steels.—For the manufacture of that class of alloy generally known as high-speed steel, Mr. JESSE M. DARKE, of Lynn, Mass., has patented a formula and procedure which has

been assigned to the General Electric Company. The components of the alloy are Swedish muck-bar, ferro-tungsten, ferro-chromium and manganese. The first three form the basis of the steel and are melted in a crucible in the usual manner. The ferro-tungsten and ferro-chromium are of the electric furnace variety and contain about 67 per cent tungsten and 68 per cent chromium, respectively. Sufficient quantity of each is used to give the finished alloy about 13.5 per cent tungsten and less than 0.5 per cent chromium. If these components are too dry to form a slag some slag is added and when the steel is nearly ready for pouring sufficient manganese is added to give the finished steel about 3 per cent manganese. The manganese is added in a special manner so that it will not combine with the slag which has a strong affinity for the same. A steel or iron tube is inserted into the molten mass in the crucible and the manganese inserted through this tube. The manganese being in lumps the size of a walnut, is soon dissolved in the alloy, and in about five

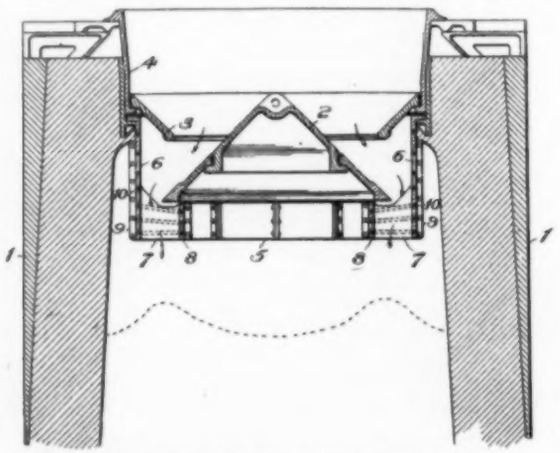


FIG. I.—BLAST-FURNACE CHARGING APPARATUS.

minutes the charge may be poured. For certain purposes a small amount of vanadium may be also added. (967,335, Aug. 16, 1910.)

For Making Steel Castings from Steel Scrap in an ordinary foundry cupola Mr. Hugh F. Jones, of Los Angeles, Cal., charges the cupola with alternate layers of coke and flux and steel scrap, using the following ratio: for 48-hour coke, 7 lb. of steel to 1 lb. of coke; for 60-hour coke, 9 lb. of steel to 1 lb. of coke; for 72-hour coke, 10 lb. of steel to 1 lb. of coke. The smallest pieces of scrap are placed on the coke and the largest pieces are reserved for the top layer. Coarse coke is used and the pieces of scrap are preferably not larger than 25 lbs. If the castings are to be machined, open-hearth steel is used, but if no machine work is required, 75 per cent of Bessemer scrap and 25 per cent of open-hearth scrap can be used. The flux used is known as Kirk's Compound, consisting principally of silica and iron oxide. It is used in the ratio of 10 lbs. of the compound to each ton of scrap when the coke contains 2 per cent sulphur. For each 1 per cent of sulphur over or under 2 per cent, 1 lb. of flux is added or deducted. The blast used on the furnace depends on the percentage of fixed carbon in the coke; for 70 per cent fixed carbon, an 8-oz. pressure is used and for each 5 per cent fixed carbon above or below 70 per cent the blast is reduced or increased 1 oz. The molten steel is tapped into a ladle containing a small quantity of aluminum and ferro-manganese. (967,780, Aug. 16, 1910.)

Blast Furnace Charging Apparatus, designed to afford a more even distribution of the stock in the furnace, has been patented by Mr. George L. Collord, of Birmingham, Ala. Any distribution of stock which allows the fine material to flow to the furnace walls prevents uniform action throughout the charge and many disadvantages result. According to Mr. Collord's device, which is shown in one form in Fig. 1, the charge is caused to pass between deflecting walls suspended in the furnace below the bell so that the charge falls substantially in an annular body and gives a double wave toward the center and sides of the furnace, as shown in the dotted line. In the furnace 1 the bell 2 closes the opening in the charging extension 3 of the hopper 4. The stock distributer 5 is supported in the furnace, as shown by straps 6. The inner deflector is a concentric wall 8 supported by radial webs from the outer deflector and both deflectors and webs are water cooled. The inventor describes a number of forms of his invention which are not shown here. (967,328. 967,329, Aug. 16, 1910.)

Metallurgical Heating.—For the purpose of heating steel and steel alloys to high temperatures, even melting them, without oxidation of the valuable constituents, a type of furnace has been devised by Mr. Byron E. Eldred, of Bronxville, N. Y. (An article by Mr. Carleton Ellis on the methods of flame regulation and combustion, known collectively as the Eldred process, was given in our vol. II, p. 895.) The furnace is of the regenerative type in which gas and air previously heated may be mixed and burned over the hearth of the furnace. In the present invention the process is modified so that a stratum of burning gas and air is produced along the roof of the furnace, while another stratum of gas only is passed along the hearth of the furnace, spacing away the burning stratum from the material being heated, so that oxidation is prevented. The furnace has twin regenerative chambers on either side of the hearth. A current of gas entering from one hot regenerator is passed over the hearth on which are placed steel billets or other steel articles to be heated. A current of air entering from a similar hot checker work is divided into two fractions, one being sent along the roof of the furnace, where it burns a portion of the gas, forming a flaming stratum hugging the roof of the furnace; the other portion being by-passed around the furnace and completing the combustion of the gas issuing therefrom in the regenerator, which is in heating-up phase. Thus the material on the hearth of the furnace is heated by radiation through a protecting and reducing atmosphere of gas.

The process is susceptible of the reverse action, in case an oxidation effect should be desired on the material on the hearth, such as in the roasting of sulphide ores. In such a case the hot air would be passed over the hearth and the hot gas would be divided into portions, one being sent along the roof of the furnace where it would burn with a portion of the air, and the other being by-passed around the furnace to burn with the balance of the air in the regenerative chambers. Thus the material on the hearth of the furnace would have a hot layer of oxidizing material next it while being spaced away from the burning layer of gas with its products of combustion.

The inventor also calls attention to the fact that by using a gas layer next the hearth, iron ore may be reduced to form iron and steel direct. The necessary carbon or metallic alloy may be added without fear of oxidation and the iron can be reduced in contact with a gas containing the minimum amount of carbon dioxide, such as in producer gas, while being subjected to as high a temperature as desired by the flaming stratum above. (968,238, Aug. 23, 1910.)

Gas Scrubber.—In a patent of Alfred Steinbart, of Pittsburgh, Pa., the latest mechanical construction of his well-known gas-scrubber tower for cleaning blast-furnace gas is described. The scrubber consists of a metal shell, 50 ft. or 60 ft. high, through which the gas to be cleaned passes upward, while water passes downward. The water is discharged from a nozzle at the lower end of a pipe at the top of the tower. When the nozzle is stationary the water is discharged in a fan-like sheet, but when the water pipe and nozzle are rotated the fan-like sheet assumes a conical shape. This conical flow of water impinges on a diaphragm built up of concentric rings, in the annular spaces between which thin metal strips or hoops are placed

so spaced as to allow the passage of a thin sheet of water between them. The effect of the diaphragm is to assure an approximately even flow of water through all its portions and to divide it up into uniform fine rain drops. The construction is such that the operation is absolutely continuous and that any repairs of the nozzle may be made without removing the nozzle or providing an opening for the escape of the gas from the scrubber. For the many carefully worked out details of construction the reader must be referred to the patent specification, which goes into the matter quite in detail. (965,248, July 26, 1910.)

Electric Arc Welding.—Articles of iron and steel are welded or repaired, according to H. L. J. SIEMUND, of New York, by establishing an electric arc between the article and a "welding rod," ⅜ in. in diameter, of soft iron coated by or, if hollow, containing the welding composition. This is made up as follows: One part of boracic acid, one part of pumice stone, one-half part of bicarbonate of sodium, one-half part of lampblack or of powdered charcoal, one-quarter part of chloride of calcium. These ingredients are mixed in the dry state and made into a thin paste by the addition of water so that it can be applied by a brush to the welding rod. (967,580, Aug. 16, 1910.)

Gold and Silver.

Charcoal Precipitation of cyanide or chlorine gold solutions is not extensively practiced save in Australia, where it is used in some large plants. The idea has been condemned on the score of being slow, cumbersome and costly as compared with precipitation on zinc. With a view to improving the process and making it faster, more convenient and cheap, Mr. THOMAS EDWARDS, of Ballarat, Victoria, Australia, has designed apparatus shown in side elevation in the accompanying Fig. 2. It consists of a partitioned box similar to zinc precipitation boxes with provision for the flow of solution from one compartment to the next, passing alternately over

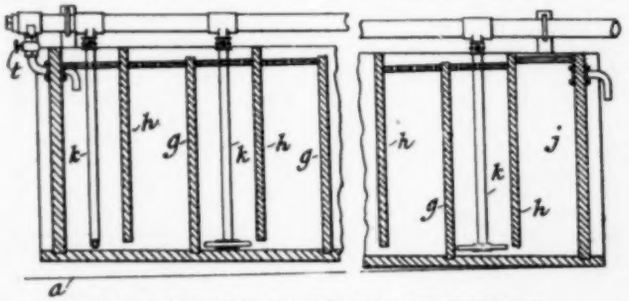


FIG. 2.—APPARATUS FOR CHARCOAL PRECIPITATION.

and under the partitions. Partitions are indicated in the drawing by *h* and *g*, the inlet of solution at *t* and the outlet at *n*. Perforated covers are provided for each compartment so that the solution may flow without carrying particles of charcoal. One of the novel features claimed by the inventor is the application of air through pipes *k* in some of the compartments, the aeration being claimed to be beneficial to precipitation. Removable gratings or cages may be provided for the expeditious removal or handling of the charcoal in each compartment. (967,744, Aug. 16, 1910.)

Precipitation of Aluminium.—The use of this metal to replace zinc as a precipitant for gold and silver in cyanide solution has been suggested from time to time by several writers, and is used in laboratory schemes for analysis of cyanide solutions. STAFFORD F. KIRKPATRICK, of Kingston, Ontario, Canada, has patented the process for commercial application in an apparatus specially devised for the purpose. The most efficient form in which aluminium could be used for this purpose is as a powder, but powdered aluminium does not easily become wet by water and does not mix with solutions. In order to overcome this difficulty the inventor makes use of an agitating device to engulf the metal in the solution and thus causes it to react with the precious metal cyanide solutions. If the precipitation is carried out in a round tank with a conical bottom, a suitable agitator can be made by attaching propeller blades onto a vertical shaft revolving in the center of the tank. This will produce a vortex into which the aluminium will be drawn and thoroughly mixed with the solution. Sodium or potassium hydroxide is added to the solution, and the inventor gives the following equation as representing the reaction which takes place:

$$6NaAG(SN)_2 + 6NaOH + 2Al = 6Ag + 6NaCN + Al_2O_3 + 2H_2O.$$ (959,757, May 31, 1910.)

Zinc.

The Treatment of Zinc Ores containing zinc oxide with a solution of sulphurous acid so as to obtain a solution of bisulphite of zinc, is the subject of a patent granted to H. T. DURANT, H. L. SULMAN and W. HOMMEL, of London, England. The main features of the process consist in agritating a mixture of the ore and water with sulphurous acid gas in suitable apparatus, subsequently breaking up the zinc bisulphite formed by the injection of steam or hot gases to precipitate insoluble zinc sulphite, which may be heated to form zinc oxide and sulphurous acid gas, the latter being used in treating more ore. The agitation is carried on in an apparatus, one modification of which appears in Fig. 3. *K* is the mixing vat into which the injector nozzle *L* projects for the purpose of forcing gas or a solution of gas through the ore pulp. The agitated mixture rises through the pipe *M* into the chamber M^2, from which conduits M^3 conduct the mixture back into the vat. The operation is conducted under a slightly increased pressure to insure perfect action of the gases, but a gauge and safety valve are provided as shown so that the constantly accumulating pressure can be released when too great. When the agitation is complete the mixture can be drawn off at *N* and the solution treated as desired. The inventors also call attention to the application of their system to copper ores (966,389, Aug. 2, 1910.)

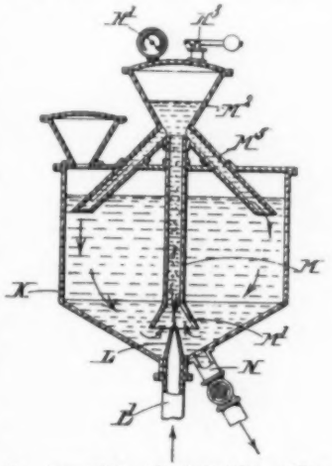


FIG. 3.—ZINC BISULPHATE APPARATUS.

Rare Metals.

Pyrophoric Alloys of the rare earth metals, such as cerium, lanthanum, didymium, etc., may have their pyrophoric properties greatly increased by subjecting them to the action of hydrogen gas at high temperatures, according to a patent recently issued to ADOLF HUBER, of Berlin, Germany. The proportions of the constituents of the alloy play an unimportant part as compared with the temperature required properly to incorporate the hydrogen gas therein. The requisite temperature must be determined for each alloy. For example, it has been determined that for an alloy of 15 per cent magnesium and 85 per cent cerium the right temperature is between 500 and 600° C. Furthermore, the duration of the exposure of the alloy to the hydrogen depends upon the alloy and must be determined for each composition. If the temperature is not properly chosen the alloy will crumble to pieces. The operation may be carried out in a muffle in which bars of the alloys are placed. The muffle is heated to the requisite degree of temperature and the gas is passed through as long as absorption is indicated. The action is complete when a fracture shows an even gray color throughout the alloy. The resulting product has a remarkable pyrophoric

power, giving off sparks in profusion and on the application of the slightest friction. (967,775, Aug. 16, 1910.)

Metallurgical Furnaces.

An Improvement in Reverberatory Smelting Furnaces is claimed for the design shown in Fig. 4, which embodies the ideas recently patented by Mr. F. W. Winkler, of Hancock, Mich. The object is to increase the area of the heating portion of the furnace chamber, to reduce the disintegrating action of the slag on the walls, to provide for ready repairing of the furnace walls and to increase the strength and durability of the furnace by providing adjustable compensation for

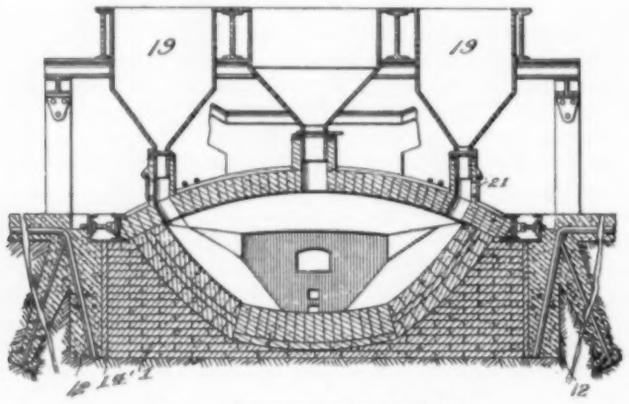


FIG. 4.—REVERBERATORY FURNACE.

expansion and contraction. It will be observed by reference to the cut that the bottom of the furnace and its side walls are curved on suitable arcs, giving a surface which the inventor claims will shed the slag to a great extent and thus reduce the well-known disintegrating action at the slag line. The furnace walls are supported by concrete walls 12, in which are embedded angle metal stays, as shown, inclining from the walls of the furnace. Between the furnace wall proper and the bracing wall is placed a cushioning layer of asbestos or magnesia 14 to permit of expansion and contraction without disturbing the walls of the furnace. The arrangement of the feeding hoppers 19 is such as to allow the material to slide down the furnace walls and thus reduce the action of the slag on the walls. Each inlet is also provided with peep holes 21 through which the action of the furnace may be viewed and through which plastic material and tools may be introduced for relining the walls when occasion requires. (966,285, Aug. 2, 1910.)

A Mechanical Roasting Furnace designed to simulate the work of the old-style hand-rabbled reverberatory is the basis of a patent granted to Cyrus Robinson, of New York. The invention relates to that type of roasting furnace in which the ore is rabbled on a hearth by means of a rabble moved through the furnace over the hearth. In most furnaces of this type the rabbles move over the entire length of the hearth in a uniform manner and return over another hearth or outside of the furnace. According to the present invention, however, provision is made to operate the rabbles in such a manner that ore in any part of the hearth may be rabbled as needed and may be moved forward toward the fire by means of hoes which are distinct from the rabble fingers. Thus, the hearth being covered with ore in various stages of roasting a section nearest the discharge or fire end may be discharged and successive sections of the ore moved forward, while a new charge is placed on the hearth at the charging end. The rabble carriage does not move uniformly throughout the hearth, but is moved forward and backward as needed. In this way the ore which has been roasted may be sintered before being moved from the hearth so as to be in better condition for blast-furnace smelting than the usual fine roasted ore produced by most furnaces. The agitation of the ore is quite separate and distinct from advancing it, the hoes used for advancing the ore being moved out of active position during the rabbling or agitating operation. (968,265, Aug. 23, 1910.)

Chemical Engineering.

Cement from Slag.—United States letters patent have been granted to Hermann Passow, of Blankanese, Germany, for apparatus devised to prepare furnace slag for cement making. The patent is assigned by mesne assignments to the Atlas Portland Cement Company, of New York. The invention relates to the means used to treat slag, producing at will two varieties, which the inventor classes as chemically inert and chemically active. The inert slag is glassy and when ground and mixed with water gives little or no rise of temperature when heated with carbonic acid gas; the active slag is spongy, blistered and friable, and when ground and mixed with water shows a considerable rise of temperature when heated with carbonic acid gas. The two varieties of slag are produced by different methods of disintegrating and cooling the slag as it issues from the furnace.

In order to produce the inert slag the disintegrating means must be so regulated as to break the molten slag as far as possible into spherical particles, or thin sheets, and to cool it as rapidly as possible below a visible heat, without using any water in direct contact. The chemically active slag is produced by breaking the molten slag into irregular masses of spongy nature, cooled as quickly as possible to a condition of plastic consistency, and from this state the cooling must proceed more slowly than for the inert variety, until below visible temperature. In some cases it is advisable to use steam or water with the blast which acts as the disintegrating medium.

These two products may be made separately or together by providing the necessary means of properly cooling to make the two varieties. By mixing the two varieties of slag they are ready for the immediate production of cement. In making the varieties separately it is only necessary to provide proper temperatures of the blast which disintegrates the slag, and the cooling wall on which it strikes or the cooling conveyor on which it falls. If the two varieties are to be made together some inequality in the flow of slag must be provided, so that different portions of it receive different treatment, or an inequality in the disintegrating blast of air or steam may be provided, whereby different portions of the slag stream are blown to different cooling surfaces. (964,805, July 19, 1910.)

Glue from Leather.—Hy. G. Halloran, of Brighton, Mass., patents an electrical method of detanning mineral or chrome tanned leather. The leather in a finely divided state, such as leather scraps, skivings, etc., is placed in a tank in which a sodium chloride solution is electrolyzed, yielding chlorine and caustic soda. The latter acts upon the leather to soften and swell it and open the fibers. The scraps are then removed from this tank, the excess of alkali squeezed out, and the leather subjected to a thorough washing in clear water to remove the remaining caustic soda. The leather is then subjected to the action of chlorine water or chlorine gas to dissolve the tanning agent, after which it is again squeezed and washed and is then converted into glue by the usual method of boiling. By this method leather may be detanned in a few hours instead of several days. The tanning agent is subsequently recovered by mixing the caustic soda and chlorine water to neutralize each other, the latter containing the chrome in solution, thereby precipitating the chrome which may then be collected and used again. The remaining liquor is a mixture of sodium chloride and sodium hypochlorite solution and may be used over again in the detanning process. (967,762, Aug. 16, 1910.)

Electric Furnaces.

Calcium Silicide.—For the refining of steel, calcium silicide has become in recent years an important desulphurizing, dephosphorizing and deoxidizing agent. Messrs. T. D. Willson and M. M. Haff, of Ottawa, Ontario, produce an alloy of silicon with calcium and one or more other metals (aluminium,

magnesium, iron, tungsten, etc.) by smelting in an electric arc furnace a mixture of calcium carbide and compounds of silicon and of the other desired metals and carbon as reducing agent. The following example is given: A mixture of calcium carbide (CaC_2) containing probably a certain amount of a compound of magnesium, ground sandstone containing oxides of aluminium, silicon and magnesium, and iron and coke were fed to an electric arc furnace and subjected to a current of comparatively low voltage and high amperage (40 volts and 6000 amp). The coke and the carbon of the carbide apparently combined with the oxygen of the several oxides, leaving a silicide which including the slag of unreduced materials gave the following analysis: Silicon, 37.2 per cent; calcium, 23.3 per cent; iron, 4.4 per cent; aluminium, 2.74 per cent; magnesium, 4.96 per cent; silica, 16.80 per cent; carbide, 10.9 per cent.

The sand in this experiment contained 96.55 per cent silica, 0.77 lime, 0.75 iron oxide, 0.82 alumina and 0.28 magnesia. The other metals desired in the alloy may be secured by properly selecting substitutes for or additions to the sand. For example, a higher percentage of magnesium in the product may be secured by the addition of magnesia to the sand in the form of magnesite. To introduce more aluminium an ordinary clay containing both silica and alumina may be substituted for the sand. (963,345, July 5, 1910.)

Purification of Carborundum.—The purification of chemically inert electric-furnace products, such as the carbides of silicon, boron, titanium, etc., is the object of a patent of Mr. FRANCIS W. HIGGINS, of the Carborundum Company. For instance, in the case of carborundum, where it is desired to remove the impurities from the surface of the grains after crushing, the chief impurities are free silicon and iron and aluminium in the form of carbides and silicides. These are removed by placing the crushed carborundum in a bath composed of aqueous solutions of sulphuric and hydrofluoric acids and permanganate of potash or other oxidizing agent, and digesting for several hours at a temperature of 150 deg. Fahr. to 200 deg. Fahr. (966,399, Aug. 2, 1910.)

Combined Arc and Pole-Plate Electric Furnace.—The Roechling-Rodenhauser combination furnace is in one respect an induction furnace; that is, the charge forms the secondary of a transformer and is heated by Joulean heat produced by the electric currents induced in it from the primary. But besides this, pole-plates are inserted in the walls, opposite to each other. These pole-plates are of metal and are separated from the charge by refractory material which is a non-conductor at ordinary temperatures and becomes a conductor when hot. These pole-plates are connected to an external source of current. When the furnace is started it acts as a pure induction furnace. The charge gets heated up and the refractory material in contact with the pole-plates, by also getting hot, becomes a conductor. Current now passes also directly from one pole-plate to the other through the charge, and the furnace acts as a combined induction and resistance furnace. Mr. JOHANNES HARDEN, of the Gröndal-Kjellin Company of London (the owners of the European patents for the induction and Roechling-Rodenhauser combination furnace) now proposes a combination of resistance heating by means of pole-plates with arc heating by means of electrodes above the charge. The furnace may, therefore, be described as a Héroult arc furnace provided with pole-plates or terminal plates. These are faced with refractory material which becomes a conductor when hot. The terminal plates are provided with cavities so that they can be air-cooled. In a three-phase furnace described in the specification three terminal plates are shown arranged triangularly and three electrodes at the top each of them being placed in an intermediate position between two terminal plates. The upper electrodes are operated independently of the current passing through the lower terminal plates. (967,908, Aug. 23, 1910.)

Calcium Carbide.—To reduce the electrical energy consumption in the proluction of calcium carbide in the electric furnace, Mr. HERMAN L. HARTENSTEIN proposes to utilize both that heat which is "rendered latent in the formation of carbon monoxide" and that which goes off with the gases as sensible heat, the patent being assigned to the Continental Investment Company, of Duluth, Minn. For this purpose the hot combustible gas (rich in carbon monoxide) coming from the electric furnaces is directly burned in contact with limestone or other form of calcium carbonate to form the lime to be used in the electric furnace. The hot gases coming from the furnace are burned directly in contact with the material to be calcined, freeing it of carbon dioxide and heating it up, and the heated calcined material is delivered to the electric furnace. Both the sensible heat and the heat of combustion are utilized. The limestone is best treated in the powdered or granulated form in an inclined rotary kiln, where it is treated in the form of a tumbling, agitated, relatively thin traveling stream. In order to supplement the heat derived from the kiln gases, producer gas is employed coming hot from a producer. The waste heat from the rotary kiln is employed to heat the air required for combustion in it, and a portion of this waste heat may also be used to heat the coke or carbon supplied to the electric furnace. (966,542, Aug. 9, 1910.)

Plating.

Rubbing Powders for Nickel and Zinc Plating.—A method of providing articles with a metallic coating by simply rubbing the surface with a plating powder has been the subject of considerable discussion recently in England. Details have now become known by the grant of two patents to Mr. AUGUSTUS ROSENBERG, of London. A wet rag is simply dipped into the plating powder mixture and then rubbed on the surface to be coated. The principle is that if this surface is metallic, or at least electrically conducting, electrolytic action is set up in the wet mixture which is rubbed on and the desired metal is deposited on the surface. A suitable powder mixture for nickel plating contains

60 parts of nickel ammonium sulphate,
3 " " metallic magnesium,
30 " " chalk,
7 " " talc powder.

When this mixture is wetted by water the nickel ammonium sulphate dissolves and forms the electrolyte. The magnesium is a highly electropositive metal and will therefore form the anode, while the surface to be coated forms the cathode. We have, therefore, an innumerable number of short-circuited electrolytic cells with the particles of magnesium as anodes and the surface to be coated as cathodes. Nickel will, therefore, be deposited on this surface. The process is in principle an electrolytic deposition or electroplating process, but it differs from ordinary electroplating processes, as no external source of electric current is required.

An ammoniacal salt as electrolyte is specially advantageous when the surface to be plated is greasy, as the reaction then helps to dissolve the grease and facilitates the plating operation. The talc powder in the formula prevents the ammonium sulphate from acting upon the other ingredients in consequence of the absorption of moisture from the atmosphere. The mixture may, therefore, be stored or exposed to the atmosphere for lengthy periods without substantial deterioration. In this respect, however, it is also important to protect the metallic magnesium particles, as they would otherwise be oxidized. This is best done by coating the magnesium particles with a protective layer of waxes and resins. For this purpose they are moistened with a solution of wax or resin in gasoline, and then the solvent is dried out, after which the coated magnesium metal particles are mixed with the other ingredients. When the powder is rubbed on the surface the friction quickly removes the wax layer.

For plating zinc on iron or copper a powder of the following composition may be used: 45 parts commercial zinc dust, 15 ammonium sulphate, 3 magnesium, 30 chalk and 7 talc powder. The magnesium particles are again coated with a wax layer as described above. (970,755 and 970,852, Sept. 20, 1910.)

The Washing of Filtering Residue.

By Oscar Nagel, Ph.D.

For filtering purposes the filter press as well as the centrifugal separator have largely their own specific fields of usefulness, while in some cases either apparatus is applicable. The residue of filtration must be washed in such cases where all particles of filtrate adhering to the solid have to be recovered

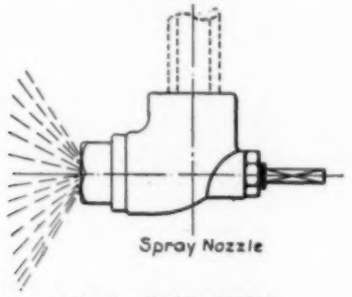


FIG. 1.—SPRAY NOZZLE.

or removed from the residue and, furthermore, where the solid is to be obtained in a certain degree of purity to be effected by the washing.

The process of washing the cakes in the filter press consists practically in pumping through the filter press a washing liquid instead of the material to be filtered.

The process for washing the residue in centrifugals is more difficult, though it is of importance in the manufacture of various organic preparations, in sugar plants, in calcium phosphate plants, etc. In this case it is essential to bring all particles of the residue in contact with the finely divided washing liquid. A very convenient method to accomplish this end is the application of the well-known Koerting spray nozzle, Fig. 1, which for this purpose is connected to the centrifugal separator as shown in Fig. 2 for washing sugar. According to the size of the nozzle and the pressure of the washing liquid, any effect desired can be obtained.

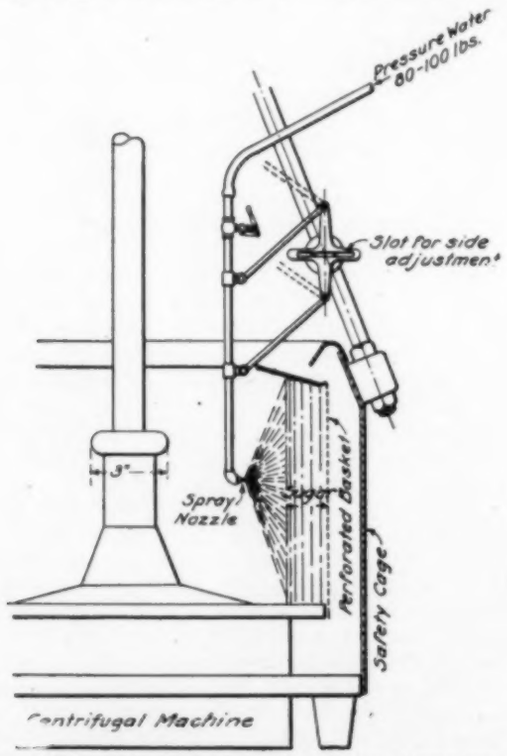


FIG. 2.—ARRANGEMENT OF CENTRIFUGAL SPRAY NOZZLE FOR WASHING SUGAR.

Improvements in Pickling Machines.

The Mesta pickling machine has become a well-known and necessary part of the large tin plate works of this country.

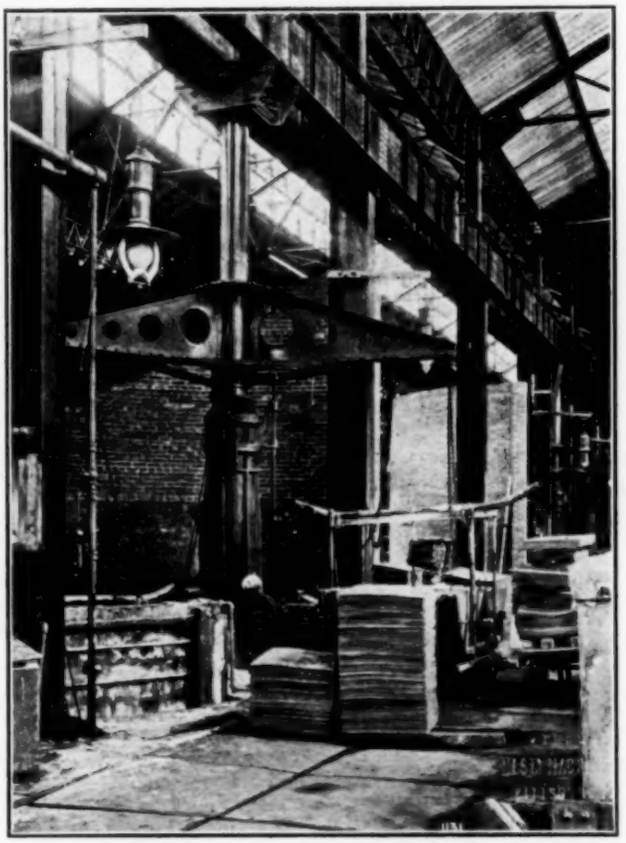


FIG. 1.—PICKLING MACHINES AT MCKEESPORT.

At present there are about 150 of these machines in operation in the United States and 95 per cent of all the tin plate made is pickled by these machines. It is in use for pickling sheets

FIG. 2.—NEW TYPE OF PICKLING MACHINE.

up to 144 in. in length and 48 in. wide, and is also employed for pickling miscellaneous other material, such as steel pipe, wire coils, automobile parts, etc. Fig. 1 shows two of a num-

ber of Mesta pickling machines installed at the plant of the McKeesport Tin Plate Company, at McKeesport Pa.

This machine has recently been improved in some noteworthy respects. As shown in Fig. 2 the latest type requires no top support, the plunger extending down through the base of the machine instead of the top support, as shown in illustration No. 3. This design also contains some other improvements in the details of construction, and is also very much heavier in all parts.

This absence of a top support permits the machine to be placed in any location in the building and is an important feature in modern plants with electric power transmission, as it permits electric traveling cranes to pass over the machine and carry material to and from it. Three of these new type machines have been recently installed in the new tin plate works of the Jones & Loughlin Steel Company, two in the plant of the Phillips Sheet & Tin Plate Company, one on the plant of the Hydraulic Pressed Steel Company for pickling material used for making automobile frames, and one in the plant of the Morris & Bailey Steel Company for pickling steel strips.

The machine is usually built with three arms and two vats, one acid vat and one water vat for washing, but for special purposes, where it is necessary to have three vats, the machine is built with four arms, as shown in Fig. 2.

The machine can be operated by either steam or compressed air. It takes steam, or air, only on its up stroke, while the down stroke is accomplished by gravity. It is regulated by means of a floating piston valve, which controls the exhaust as well as the intake. As the machine is single acting and takes steam, or air, only on the up stroke, the consumption is necessarily small. With 70 lb. of steam the machine will handle 2000 lb. of plates in each of the three crates. It is entirely automatic, not requiring a skilled mechanic to operate it. The crates for holding the plates are made of acid-proof metal, and vary in size and design, depending upon the material to be pickled.

The machine, designed for tin plate works and for pickling sheets up to 60 in. x 36 in., requires a floor space of about 25 ft. square, and has a height of about 18 ft. The inside dimensions of the two vats are 6 ft. 3 in. wide, 7 ft. long and 5 ft. deep. The size of the crates is 61½ in. square. The diameter of the main cylinder is 18½ in.; total lift of arms, 4 ft. 3 in.; diameter of steam pipe, 2 in., and diameter of exhaust pipe, 2 in.

This machine pickles 16,000 lb. of black plate per hour with 140 lb. of acid per ton of black plates. The maximum load of each crate is 2000 lb.

The floor space required for machines arranged for pickling sheets up to 144 in. in length and 48 in. in width is about 40 ft. square; the height about 22 ft. The inside dimensions of the vats are 4 ft. 4 in. wide, 14 ft. long and 6 ft. deep. The crates are 37 in. wide and 128 in. long. The diameter of the main cylinder is 18½ in.; the total lift of the arms, 5 ft. 3 in.; the diameter of the steam pipe, 2 in.; the diameter of the exhaust pipe, 2 in. This size of machine pickles from 12,000 lb. to 15,000 lb. of long sheets per hour. The maximum load of each crate is 2000 lb.

The floor space required and capacity of a machine for pickling wrought-iron pipe or other material depends upon the size and kind of material to be pickled. The Mesta pickling machine is built by the Mesta Machine Company, of Pittsburgh.

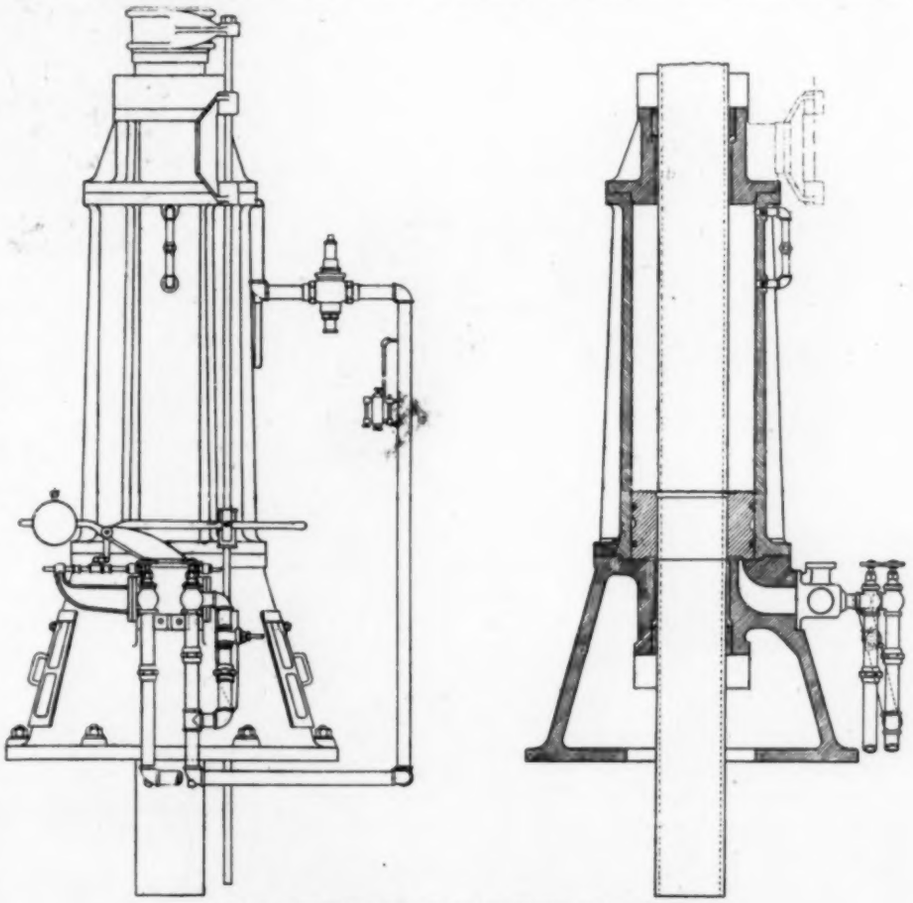


FIG. 3.—DIAGRAM OF MESTA PICKLING MACHINE.

Crushing in Stages.

BY H. W. HARDINGE.

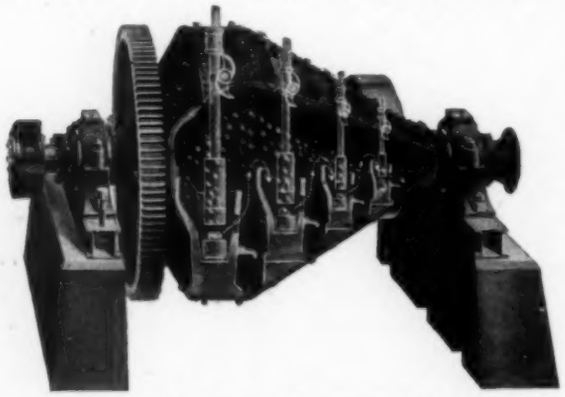
If it was possible to set aside individual interests and view the matter from an entirely disinterested standpoint, yet explain my ideas in another way than by reference to the Hardinge conical mill, it would be better to do so. But as such practices as I advance are based upon my work with both stamps and ball mills I can relieve the reader from unnecessary explanations by referring to the illustration, on page 600, of the conical mill made of two cones, over which I have outlined in shadow serial stamps of different sizes and weights, thus representing the step reduction obtained in the principle and action of the grinding bodies within the conical mill.

A great deal of interest is being taken by metallurgists as to the best method of fine reduction. In South Africa the stamp is being constantly made heavier until it now ranges from 1000 lb. to 2000 lb., the latter apparently having a preference. At the same time it is conceded that with this enlargement only increased capacity is obtained at a sacrifice of fineness. I am of the opinion that this practice should be reversed unless the heavier stamp is considered as a coarse crusher with proportionately increased screen aperture.

After having watched comminution, both in my own prac-

tice and that of others for a great many years, using stamps, Chili and Huntington mills, rolls and numerous other devices for fine comminution, I have come to the conclusion that maximum efficiency for power expended depends upon the exposed crushing surfaces, rather than upon the force or energy behind the surface when it is clogged with the result of the previous charge of material undergoing division.

To illustrate, take a 1000-lb. stamp with an 8-in. shoe dropping 100 times per minute. Considering both shoe and die as each individual surfaces, we would have approximately 100 sq. in. of surface being acted upon by 1000 lb., or 10 lb. of weight for each square inch of crushing surface. This stamp dropping upon a 2-in. cube of ore, weighing approximately ¾ lb., if reduced to a mass averaging ½-in. cubes, would have a relation of 1:64. If the stamp is fairly proportioned to the work, the next stamp should be 1000/64 in., or about 16 lb. This we would supply in 16-lb. balls, provided the ratio of weight was alone required. This 4-in. ball has a surface exposure of approximately 50 sq. in., or 4 sq. in. for each pound of weight, or 40 times the surface relation to weight as that of the 1000-lb. stamp shoe and die to its 2-in. cube.



COMPARISON OF CONICAL MILL WITH STAMP MILLS.

My diagrammatic illustration of serial or stamp step reduction in weight of stamps might at first appear to be greatly out of proportion to the work required and it might seem that succeeding stamps should be larger than indicated, while, in fact, they are each ten times too heavy for the successive divisional work to be performed.

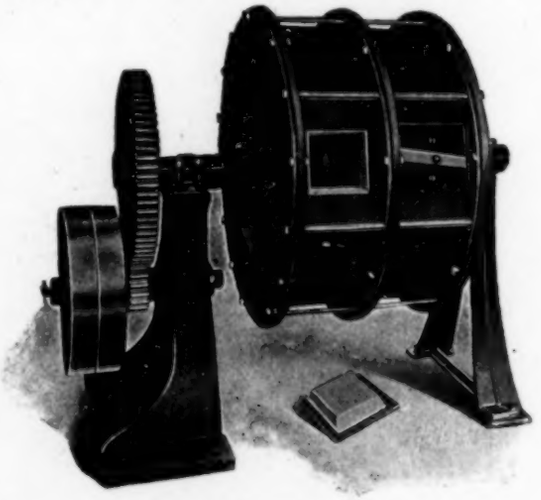
If the metallurgist will cast back over his work, consider the cause and remedies by which he has essayed to better effect a more economic comminution, I am inclined to think he will agree with me that the theory at least appears tenable. Resistance to subdivision under similar conditions is proportional to the mass. Do not waste energy in endeavoring to crush a rock by pounding it upon a more finely divided mass. It is equivalent to trying to break it upon a springy board platform. A 1000-lb. stamp uses energy sufficient to crush 50 tons per day if the crushing faces between shoe and dies are clean. The same principle applies to any other system of dividing. The reason the jaw crusher has such an enormous crushing capacity is owing to the fact of its gravimetrically clearing itself. This is a subject worthy of consideration and an effort to remedy the defect.

Tumbling Barrel for Burnishing with Steel Balls.

The adjoining illustration shows a tumbling barrel, built by the Globe Machine & Stamping Company, of Cleveland, Ohio, specially suitable for the polishing and burnishing of small articles by means of steel balls. By the use of this burnishing process all buffing is eliminated on small metal parts before and after plating. The process of burnishing a great many small pieces at once is thus greatly facilitated.

The burnishing tumbling barrel of the Globe Machine & Stamping Company is of the horizontal type, the barrel having an octagonal cross-section. It weighs empty 1800 lb. and occupies a floor space 42 in. x 62 in. The proper pulley speed is 60 r.p.m. and the barrel speed is 15 r.p.m.

The burnishing process itself is exceedingly simple, if some ordinary precautions are taken. There should always be enough steel balls in the barrel so that the articles to be burnished do not rub one another. A safe rule is to use two pails of balls for each pail of material. These steel balls are made especially for this process by the Abbott Ball Company, of Hartford, Conn., in six sizes ranging from 1/16 in. to ¼ in. in diameter.



TUMBLING BARREL.

For each pail of material a pail of hot water is needed. Before adding the water about 6 oz. of chips of ivory soap or some other mild and pure soap are dissolved in the water. Instead of these soap chips Hascoline burnishing compound, or burnishing chips, made by the Haas Brothers Company, of Newark, N. J., may be advantageously used. In ordinary practice 6 oz. of Hascoline chips are dissolved in 2 gal. of water.

This process of burnishing large quantitiees of small articles in one operation saves considerable time and reduces the cost of finishing the plated articles very considerably.

Combined Agitation and Filtration of Cyanide Solutions.

Since the introduction of the cyanide process for gold extraction there has been practically little change or improvement in the chemistry involved, but inventors have given the mechanical side of the process a great deal of attention. This was necessary on account of the greater number of mechanical difficulties met with as the variety of ores treated increased and the scope of the process extended. The greatest problem to be solved was the rapid dissolution of the gold and silver in the ore, and the subsequent separation of the solution from the ore. Of the many types of mechanical devices intended to accomplish the desired end, those of the Hendryx Cyanide Machinery Company, formerly of Denver, Colo., and now of New York City, are among the latest. They comprise a combination agitator and filter, and a tailings dewaterer.

Combined Agitator and Filter.

The Hendryx combination agitator and filter has been designed for the purpose of effecting in one compact machine the dissolution of the precious metals and filtration of the cyanide solution. It consists essentially of four parts: (1) A cylindrical tank with conical bottom, (2) a mechanical agitating pump located in a central well in the tank, (3) a series of filter cells

of the leaf type, and (4) a system of coils of pipe for heating the cyanide solution during agitation.

The construction of the machine will be understood by reference to the accompanying drawing. The tank is made of sheet steel and has a 45-deg. conical bottom. Over the inside of the latter is fastened a canvas sheet which serves to distribute evenly the inflowing wash solution when displacing the gold cyanide solution. This will be referred to later in the description of the operation of the machine.

The agitating pump consists of a circular well within which is a shaft carrying a driving pulley near the top and several screw propellers at different points along its axis. At the top of the well is a circular apron which slopes gradually toward its periphery. The revolution of the propellers causes a strong upward current of solution through the well, finally flowing over the apron, where it is constantly aerated. The charge of ore and solution is kept in rapid circulation and slimes and sands are agitated together without difficulty. No trouble is experienced from the settling of the solid particles of the pulp, even after operations are closed down for many hours.

The filter cells are located beneath the distributing apron and stand vertically in the tank. Each cell consists of a wooden frame with iron tees and elbows, and a piece of cocoa matting which fits inside the frame. This is completely enveloped in a

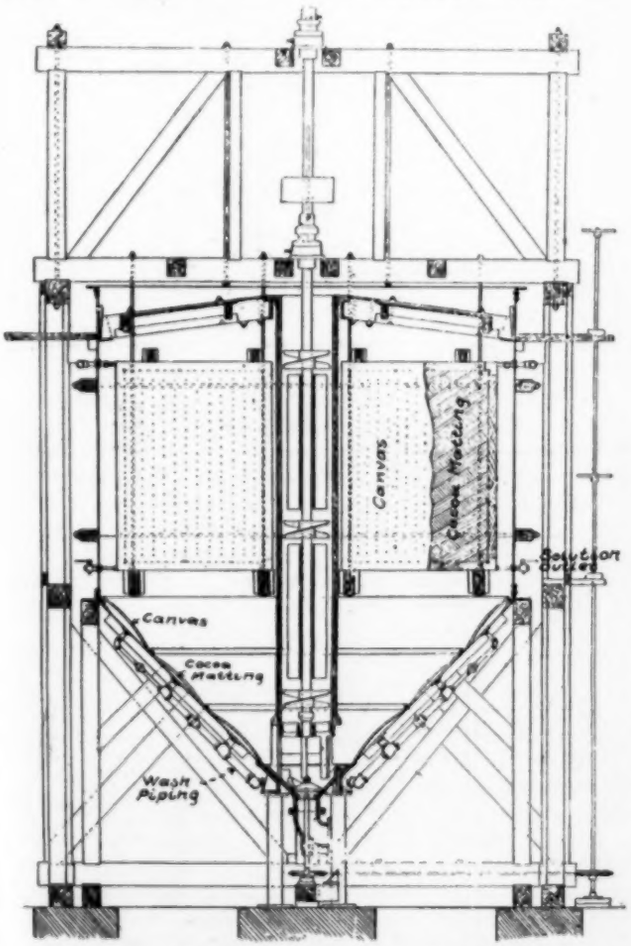


FIG. 1.—COMBINATION AGITATOR AND FILTER.

sheet of canvas, and the matting and canvas are quilted together at intervals. The usual means are provided for the outflow of the filtered solution and the inflow of a wash solution to clean the cell. The coils of heating pipes are suitably disposed in the tank so that the solution is readily heated.

The operation of the machine is varied to meet special conditions, but in general is as follows: The pulp, composed of about one part ore to two parts solution, is run into the agitator from a storage tank until the agitating tank is filled to the bottom of the distributing and aerating apron. The pump is then started and agitation continued until the dissolution of the metals is complete. At the same time the solution is heated to about 90 deg. F. by means of hot water or steam circulated through the heating pipes. When this process is finished the filter cell outlets are opened, allowing the cyanide solution to filter off by gravity to tanks, where it is precipitated by zinc dust. Wash solution is simultaneously run in through the canvas sheet on the bottom of the tank to displace the gold solution in the pulp settling below the filter cells. The charge is filtered until its level is nearly to the bottom of the cells. This

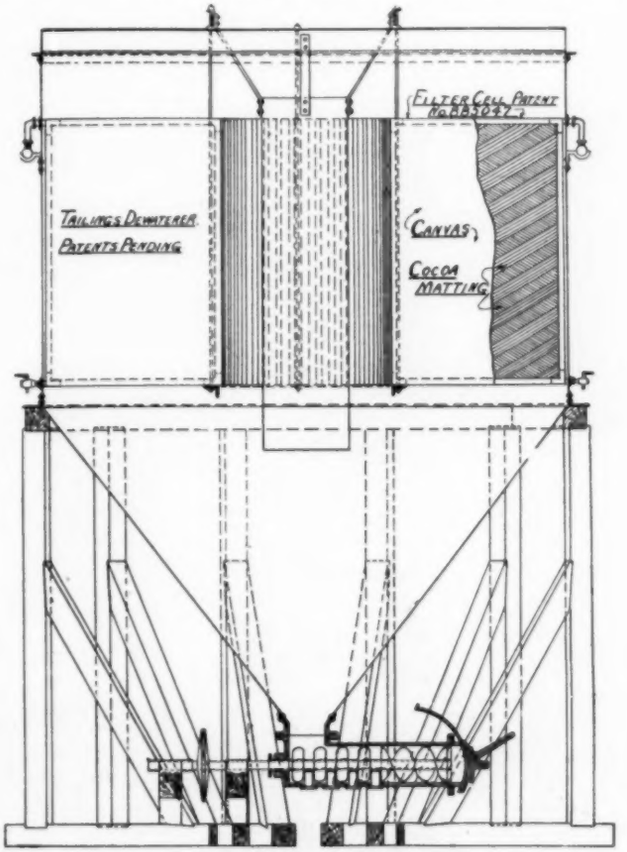


FIG. 2.—TAILINGS DEWATERER.

filters off about 80 per cent of the solution and dissolved values. Should a slimy ore reduce the rate of filtration, the filters may be cleaned by a reverse current of solution when they are apparently clogged. At the close of the first filtration a barren wash solution is run in through the canvas in the bottom of the machine until the charge again rises to the top of the filter cells. The filters are thoroughly cleaned by a reverse current of wash solution and agitation proceeds as before for a short time. This wash is then filtered and another barren wash applied if necessary. If not, fresh water is run through the canvas in the bottom, and through the inside of the filter cells, in sufficient quantity to compensate for the moisture in the tailings. The agitator is then started, and when the charge is thoroughly mixed, a discharge gate is opened at the bottom of the tank and the pulp is discharged.

Tailings Dewaterer.

Where it is necessary to conserve water, or where it becomes necessary to stack the tailings in a dewatered condition, the Hendryx tailings dewaterer is installed to receive the discharge from the combined agitator and filter. This dewaterer consists of a round tank with a conical bottom within which are placed vertical filter cells to clarify the solution. At the bottom of the cone is an outlet in which is a screw connected to a shaft

by a sprocket. As the tailings settle they are removed from the conical bottom and forced through the outlet by the revolving screw in a continuous uniform stream.

The Hendryx company gives the following figures relative to these machines. In the 16-ft. combined agitator and filter the filter cells are 6 ft. high and 7 ft. long. A machine of the size mentioned and operated as described has approximately 6000 sq. ft. of filtering canvas and will yield as high as a ton of clear solution per minute. The time necessary to treat a charge ranges from two to four hours, depending on the character of the ore. A machine capable of handling 100 tons of ore per day requires 6 hp. The reason for the small power consumption is that there is only an 18-in. lift, as the pump casing and tank are normally filled to the same level.

The tailings dewaterer will dewater 200-mesh tailings down to 12 per cent to 15 per cent moisture. An 18-ft. machine has a capacity of 200 tons of dewatered tailings and 400 tons to 600 tons of water or solution per 24 hours. The Hendryx company has records of many tests showing the efficiency of the machines described.

Concentrating Table.

The two adjoining illustrations show a new and interesting concentrating table, designed by Mr. C. W. Eccleston and built by the Eccleston Machinery Company, of Los Angeles, Cal.

The table top is placed in a frame and suitable means arranged on each side of the table to place the table under heavy tension transversely; several clevices are attached to the table on either edge, into which are hooked springs of suitable strength, which are connected to the frame by the hook bolt provided with a threaded end, and a wing nut for regulating the tension on each spring independently.

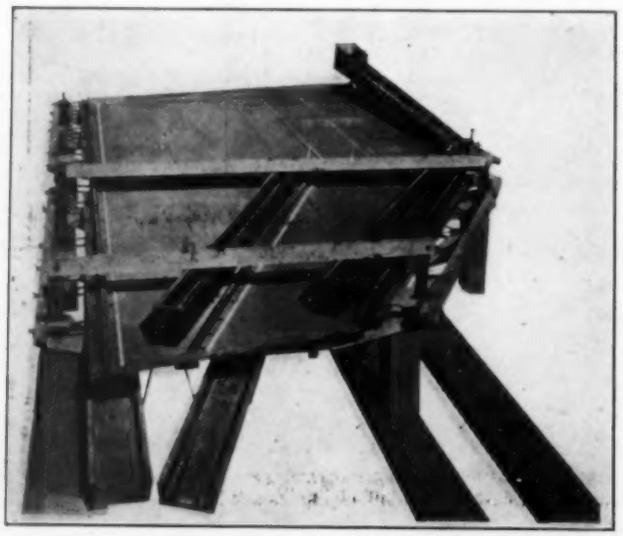


FIG. 1.—CONCENTRATING TABLE.

The table is made in two sections; the first section, 8 ft. x 8 ft. is provided with a feed box, and is so constructed that the first 3 ft. below the feed box have a gentle slope; the remaining 5 ft. are almost flat, forming a pool of 5 ft. x 8 ft. The heavy sands and sulphides are precipitated on the first 3 ft. and are carried forward to the second deck; the lighter particles such as slime are precipitated in the pool and are also carried forward to the second deck.

The second deck is placed directly in front of the first deck and below it, so that the material being driven forward off the first deck is caught by the second deck. The second deck is 8 ft. wide at one end, 7½ ft. long and 3 ft. wide at the concentrates discharge end.

This deck is divided in two sections and is provided with two wash-water boxes. The heavier sands and sulphides precipitated on the upper side of the first deck are received on the upper side of the second deck; the fine sands and mixed slime that has been precipitated in the pool are delivered to the lower section of this second deck. The two products are thus kept entirely separate and the wash water is regulated to suit the two products. By this means a classification is made of the feed and it is dressed separately. Provision is made to take off the two classes of tailings; the sulphides are also delivered separately.

The second deck is adjustable independent of the first deck. After the first deck is adjusted to any requirement the second deck can be adjusted to dress the product delivered to it from the first deck. The adjustments cover any range of work and are positive.

One head motion operates the two decks. The combined weight of the two decks is 240 lb. There is over 100 sq. ft. of concentrating surface.

The objects in placing the table tops under tension transversely are many. It is said that a much more delicate movement can be secured in this way; further, that the method of attaching the tensional means to the edge of the table places the entire supporting frame and all the weight of the machine in the plane of the table tops to absorb vibrations and control momentum. By using this tensional means and supporting the table in this way a very light table top can be used one that can be stretched into shape and always held in shape.

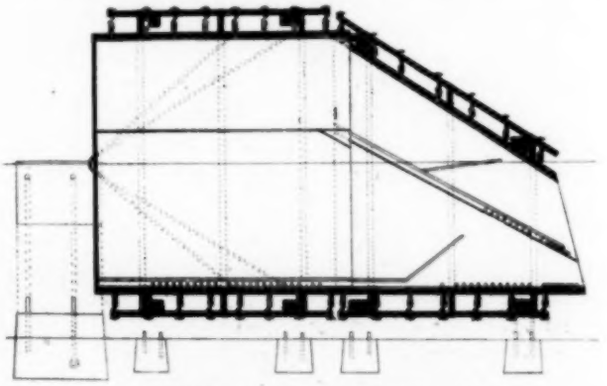


FIG. 2.—DIAGRAM OF CONCENTRATING TABLE.

By having a light table top under tension it can be run at a very high speed, viz.: 400 r.p.m. to 500 r.p.m., giving a delicate vibration entirely void of shocks and jars.

It is well known that a classification of the feed to a concentrator is absolutely necessary to get the best results. This machine takes the classified product and makes still another classification of it and dresses the products separately.

The machines are built for the different products viz.: roughing table for very coarse material, sand table for material from 15 mesh to 100 mesh, sand table for very fine and overflow slimes.

From differential indicator diagrams plotted by the builders they conclude that a very great range of the differential can be obtained on this machine. A change in the differential can readily be made without changing the stroke.

The deflection of the table tops in this machine is peculiar, as the transverse tensional means provide for an increase and decrease of the transverse and longitudinal tension as the table is vibrated by the head motion.

As the table travels forward on the impelling stroke the speed increases rapidly, due to the differential mechanism, at the same time the transverse tension on the table tops is decreasing. Consequently, when the table arrives at the termination of the forward or impelling stroke it is traveling at its greatest speed and is under the least tension transversely and

longitudinally. The table tops are brought to a sudden stop at this point and start on the return stroke; the table tops at this point drop below the plane of vibration, due to a body taking the line of least resistance on being brought to a sudden stop. The tables are now returning, the speed is decreasing, and the tension transversely and longitudinally is increasing, consequently when the table tops arrive at the point of starting they are traveling at their slowest speed and are under the greatest tension, so that they do not leave their plane of vibration.

This drop in the table tops is very efficient, as it relieves the friction between the table tops and the pulp to a certain extent, allowing the pulp to travel forward further and faster than it would otherwise do. The drop or deflection can be controlled by the transverse tension. A very small drop is all that is permitted—being from 1/64 in. to 1/100 in.

Metallurgical Microscope.

In our August issue, page 503, we described the new micrometallograph of Ernst Leitz, Wetzlar, Germany. While this elaborate instrument has proven very successful there is also a demand for a less complete and less expensive metallurgical microscope sufficient for all the usual work which the metallographist has to perform.

The adjoining illustrations show such a new metallurgical

FIG. 1.—METALLURGICAL MICROSCOPE WITH ILLUMINATOR.

microscope developed by the firm of Ernst Leitz, with the aid of Dr. Wm. Campbell, the well-known metallographical expert and professor of metallurgy at Columbia University.

Fig. 1 shows the microscope mounted for laboratory research work with a new opaque illuminator in connection with a specially designed illuminating stand which insures an even illuminated field with the most powerful objectives. The stage may be raised and lowered by rack and pinion so as not to disturb the relative position of the vertical illuminator and the source of light. This rock and pinion arrangement fulfills at the same time the work of the coarse adjustment of the microscope. The fine adjustment is effected by the delicate micrometer screw on the top of the column.

To overcome the great difficulty of having two absolutely parallel surfaces of the specimen to be examined the stage is also provided with an ingenious device for inclination to insure in all cases absolute parallelism between the surface to be examined and the front lens of the objective.

Fig. 2 illustrates the microscope arranged for examination of large metal surfaces and castings at the works. The stage of the microscope with rack and pinion is omitted and the tube with coarse and fine adjustment is attached directly to the horseshoe case. In this instance the coarse adjustment is made by rack and pinion movement of the tube.

The works of Ernst Leitz have branches in this country at 30 East Eighteenth Street, New York City, and at 1923 Ogden Avenue, Chicago, Ill.

NOTES

The **American Foundrymen's Association** will hold its convention next year in Pittsburgh from May 21 to 23.

The Goldschmidt Thermit Company, of New York, announces an important change in its management. Commencing Oct. 1 Mr. E. Stütz, vice-president and general manager, retires from the direction of the company, which passes under the management of Mr. William C. Cuntz. Mr. Cuntz brings to his position a thorough knowledge of the steel business and a wide acquaintance with the railway and street railway officials of this country, having been connected for 18 years with the Pennsylvania Steel Company.

The **Rockwell Furnace Company,** of New York, announces the opening of a Chicago office in the Fisher Building, rooms 718 and 719, which will be in charge of Mr. A. L. Stevens.

Phosphate lands to the extent of 2,500,000 acres have been withdrawn from entry in Idaho, Wyoming and Utah in accordance with the Govenment's policy of conservation. It is believed by the Government experts that these phosphate fields may prove to be the most extensive in the world.

Sulitelma Mines.—It is reported from the Sulitelma Company's mines in Norway that for the month of August 645 tons of concentrates containing 7.38 per cent copper were produced by the Elmore process.

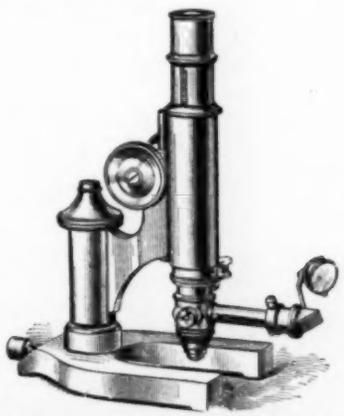


FIG. 2.—EXAMINATION OF LARGE METAL SURFACES AND CASTINGS.

The **Thwing Instrument Company** has been organized to manufacture the line of pyrometers which has heretofore been manufactured by Dr. C. B. Thwing, the inventor of the Thwing multiple-record recorder and of the Thwing fixed-focus radiation pyrometer. He will remain as president of the company, the other officers being: Vice-president, Mr. E. C. Stover, assistant general manager of the Trenton Potteries Company; secretary-treasurer, Mr. L. R. Woodhull. The offices are at 445 North Fifth Street, Philadelphia.

The **Pittsburgh Testing Laboratories,** inspecting and consulting engineers and chemists, of 325 Water Street, Pittsburgh, Pa., announces the removal of their New York office from 1 Liberty Street to 50 Church Street, Hudson Terminal Building. The company's interests in New York and New England have been placed in the hands of the second vice-president of the company, Mr. William F. Zimmermann.

The Camp Bird, Ltd., Ouray, Col., treated during the month of July, 1910, 6818 tons of ore, yielding 9985 oz. of bullion and about 824 tons of concentrates. The financial statement for the same month shows about $186,000 applicable to profit.

Transvaal Gold Production.—The number of companies reporting to the Transvaal Chamber of Mines in June, 1910, was 71. There were milled 1,814,195 tons of ore; 9870 stamps were in operation with an average duty of 7 tons per 24 hours; 178 tube mills were at work. Comparison with last year's

record for the same month shows an increase in tonnage milled, number and duty of stamps, and number of tube mills in operation. The yield for the month was 625,181 fine ounces gold.

The estimation of slime can be accomplished by the use of the ordinary laboratory centrifuge, using specially calibrated tubes. Mr. G. J. Young recommends tubes calibrated with known weights of pyrite. By using a mixture of 3 or 4 of water to 1 of slime and revolving the same in the centrifuge the component parts of the pulp will settle to the bottom of the tube according to their specific gravity, and a line of demarcation between slime and fine sand will be plainly noticeable. Much coarse sand renders the results unsatisfactory, but for quite clean slime the method is said to be good.

Water Softening and Filtration Systems is the title of a new trade pamphlet recently issued by the Booth Apparatus Company, Syracuse, N. Y. A brief description is given of the essentials of water softening plants, also some illustrations of plants varying from 250 hp to 10,000 hp. Mr. Wm. Booth is the well-known chemical engineer and water expert of Syracuse, whose contributions to chemical engineering literature have been repeatedly noticed in these columns.

The Goldschmidt Thermit Company, New York, has issued a very neat bulletin on thermit butt-welded pipe joints, illustrating and describing this kind of work. The process, which is well-known to the readers of this journal, has found much favor, especially for ammonia pipes, etc., where any leak would mean a considerable loss.

The Bonnot pulverizer is a machine adopted from the cement industry for fine metallurgical grinding. The machine is said to be efficient as a fine grinder and also as an agitator during the process of grinding. The Bonnot Company, of Canton, Ohio, has issued a bulletin describing and illustrating the machine.

Cleaning Metals.—A small folder has been received from the New York Chemical Works, H. M. Anthony Company, New York, describing the uses of "Kalye," a cleaning compound, to be used in the preparation of metals for electroplating or lacquering. This substance, which is dissolved to make a hot-water bath, does not saponify oil or grease, and is said to give good results with little manipulation. It has been upon the market for over a quarter of a century. Sample cans, enough for 2 gal. of cleaning solution, sent upon request.

Valves.—A handsome 220-page catalog comes to us from the Nelson Valve Company, Philadelphia. It is divided into three sections illustrating and briefly describing the products of the company. Section I deals with bronze valves; globe and angle, check, swing and gate valves in standard sizes from ¼ in. to 3-in. pipe and for working pressures; standard 125 lb., medium 175 lb., and extra heavy 300 lb. Special bronze gate valves have been built up to 5000-lb. service. The Nelson double-disk tapered-seat valve for all gate valves is strongly featured. Section II deals with iron-body valves bronze mounted for various services and in sizes from 2 in. to 30 in. One of the specialties of the company is an extra heavy gate valve for superheated steam up to working pressure 400 lb. at temperature 800° Fahr. The body of the valve is of steel and the disks, seat rings and bushings of monel metal, which admirably withstands corrosive conditions. Gate valves are arranged for operation by hand or from a distance through gearing or by hydraulic or electric means. Section III illustrates accessories and fittings.

Boiler-Cleaning Devices.—The General Specialty Company, of Buffalo, N. Y., have recently issued "Pictorial Proof," a neat booklet giving illustrations, tests and reproductions of testimonial letters regarding their boiler-tube cleaning devices. The "Demon" is designed to remove the scale from water-tube boilers, and consists of a triplex cutting head driven by a small high-power water motor, to which it is attached. The cutter and cutter arms are set in a non-yielding manner to the net inside diameter of a clean tube, which means that all the scale will be removed. The "Torpedo" cleaner is used for fire-tube boilers. It consists of a head with centering lugs and a vibrator driven by steam or compressed air to give 11,000 oscillations a minute. The short, light stroke knocks off the non-elastic scale without injuring the tube.

Mechanical Draft for Boilers.—"More Power for the Same Money or the Same Power for Less Money" is the heading of a neat booklet by the Turbo Blower Company, New York. After a few pages on the advantage and economy of mechanical draft over natural chimney draft follows an illustrated description of a somewhat unusual type of blower. The "turbo blower" is self-contained and occupies no space outside the boiler setting, the entire length of the case being masoned into this setting. It consists of a five-bladed fan with an enlarged hub, providing a chamber containing the vanes of a miniature steam turbine of the impulse type. The spider which supports the bearing also has an enlarged hub, which forms the other half of the chamber and accommodates three or four stationary nozzles which direct boiler steam against the vanes. The spider is bolted to the cast-iron cylindrical casing imbedded in the furnace wall, and the revolving fan forces air into the ash pit under the grate and thus through the furnace to the stack. The apparatus is of rugged design, as well as compact, for the smallest size, 15-in. diameter fan is intended to serve boilers up to 150 hp. The device is simple and ought to be successful provided that the turbine arrangement offers a fair economy in steam consumption.

The Utah Copper Company has issued its ninth quarterly report, under date of Aug. 4, 1910, for the second quarter of 1910. Each of the company's three concentrating plants was in operation at about full capacity throughout the quarter. Alterations at the Magna plant have progressed nearly to completion and the capacity of the plant has been increased; while only one-third of the plant is operating in its remodeled form, the alterations for the balance of the plant will be put into service in a short time. The alterations at the Arthur plant have not been made, as the necessary material has not yet arrived. The ore treated in this quarter contained about 1 lb. of copper per ton more than that treated in the first quarter. The total copper contained in the concentrate produced and sold was 25,124,052 lb. The gross production by months was as follows:

April	7,902,643 lb.
May	8,862,913 "
June	8,358,684 "
Average	8,374,684 "
Net profits from mining and milling	$1,184,199.05
Additional miscellaneous income	8,351.94
Income from Nevada Cons. dividend	356,428.50
Total net profit for the quarter	$1,584,979.49
Dividend paid	1,155,243.75
Net surplus for the quarter	393,735.74

Average price of copper on which above earnings are based was 12.5 cents per pound as compared with 13.33 cents per pound for the previous quarter. The average cost per pound of net copper produced, after deduction of smelter allowances, was 7.53 cents. During May, when slightly richer ore was mined, the cost of copper per net pound was 7.17 cents. During the same month the cost at the Magna plant was 7.06 cents. The railway which the Utah Copper Company is interested in building between Bingham and Garfield, where the mines and mills are located, is progressing rapidly and it is expected that the open grading work will be completed before cold weather sets in. The railroad will probably be completed and in operation within a year and will serve to relieve the unsatisfactory transportation conditions that now exist.

Water-Purifying Devices.—From the Hoppes Manufacturing Company, Springfield, Ohio, come a couple of catalogs showing their feed-water heaters, steam separators, etc. The live-steam water heater and purifier uses a number of dished basins or trays one above the other in a cylindrical steel shell. Water is fed into the top pan, fills it and trickles over following the curved bottom to the lowest point, from which it drops into the next pan for a similar operation. Solid matter in suspension settles in the trays and matter in solution is precipitated on the bottom surface of the trays by the heat of steam, which always comes into direct contact with it. When live steam is used in the purifier no chemicals are necessary to purify the water as the high temperature of the boiler pressure does this effectively. An exhaust-steam feed-water heater and purifier is made on the same plan with the addition of a baffle plate to remove the oil. Four types are made for various requirements, one of them having a cast-iron bottom and pans and particularly adapted to handling water of a corrosive nature or containing acids. The sizes range up to 40,000 hp. The Hoppes steam separator shows a somewhat novel design in that baffle plates and various obstructions are avoided, the steam gradually expanding into a large chamber where the water is intercepted by a cone with water-sealed edges to prevent the escape of entrained moisture. The separator is made in various types and an oil eliminator, also an exhaust head, are described in the booklet.

PERSONAL

Mr. **H. B. Abbott,** formerly Western manager of the *Electric Railway Journal,* has accepted a position on the advertising staff of METALLURGICAL AND CHEMICAL ENGINEERING.

Mr. **John H. Banks,** of Ricketts & Banks, New York, has been in Idaho on professional business.

Mr. **H. K. Benson,** Professor of Industrial Chemistry in the University of Washington, Seattle, has been engaged in field work for the Soil Survey during the past season.

Mr. **Henry D. Boddington,** formerly engaged in professional work in the Southwest and Mexico, has gone to Philadelphia, where he will spend some time.

Mr. **D. W. Brunton,** of Denver, attended the sessions of the American Mining Congress at Los Angeles.

Mr. **R. B. Carnahan, Jr.,** of the American Rolling Mill Company, of Middletown, Ohio, the inventor of the process of making "American ingot iron," has returned to this country on October 1 from a six months' trip to Europe, where he studied the latest practice in rolling mill methods.

Prof. **F. G. Cottrell,** of the University of California, has organized an association of students and professors for the purpose of studying the various phases of the smelter fume problem. There will be co-operation on the part of the College of Agriculture and the College of Mining.

Mr. **A. C. Dart,** general manager of the Rambler Copper & Platinum Company, Holmes, Wyo., spent a week in Denver last month on business for his company.

Mr. **E. L. Fletcher,** formerly of Tonopah, Nev., has been placed in charge of the tungsten mines at Osceola, Nev.

Mr. **Charles S. Herzig,** of Constant & Herzig, New York, has been appointed consulting engineer for the Jumbo Extension Mining Company, Goldfield, Nev.

Mr. **George T. Holloway,** consulting metallurgist, chemist and assayer, has removed his laboratories and testing plant from Chancery Lane to 9-13 Emmett Street, Limehouse, London, England.

Mr. **W. H. Seamon,** Chihuahua, Mexico, has recently disposed of his laboratory to Wilding & Keller, of Parral, who will conduct it as a branch office.

Mr. **James A. Snedaker** has removed his offices in Denver to 818-819 First National Bank Building.

Mr. **A. H. Wethey,** manager of Senator Clark's interests in Butte, returned last month from his trip to Europe.

Digest of Electrochemical U. S. Patents.

Prior to 1903.

Arranged according to subject matter and in chronological order.

Compiled by Byrnes, Townsend & Brickenstein, Patent Lawyers, National Union Building, Washington, D. C.

ELECTRIC FURNACES (Continued).

No. 679,452, July 30, 1901, George D. Burton, of Boston, Massachusetts.

Resistance type, especially for ore roasting. The furnace consists of a rotary cylinder of steel or fire-clay, through which pass resisters consisting of hollow open-ended steel tubes in conductive connection with hollow axles, through which gases may be introduced and exhausted through suitable condensers and receivers. The furnace is either horizontal or inclined.

No. 679,973, August 6, 1901, Denis Lance, Raphael Louis, Emmanuel de Bourgade and Leon Schmitz, of Paris, France.

Resistance type, particularly for effecting chemical reactions in which gases are used as in making cyanides. The furnace is narrow and either straight or annular; has walls of porcelain heated externally by wire resistors. The charge is placed in the lower part of the furnace and covered with fragments of porcelain through which gas is introduced, passes through the charge and out at the bottom. The resistor wires may be connected at one end to a common terminal and at the other to contacts over which revolves a contact arm.

679,973, Aug. 6, 1901. D. Lance, R. L. E. de Bourgade & L. Schmitz, Paris, France.

Resistance type, for reacting on solids with gases, e.g., for producing cyanides. The heating chamber is an annular or straight porcelain crucible, heated by windings of wire. In the annular type, the windings may be external and internal helices; or both types may have vertical parallel resistance wires, connected to bars at their opposite ends. The current may be passed successively through the wires by a distributor. The crucible and windings are imbedded in sand and asbestos. The crucible has a gas inlet and perforated diffuser at the top and an outlet at the bottom. The solid to be heated, e.g., carbon, occupies the lower half of the crucible, which is filled above it with fragments of porcelain to divide the gases and give uniform pressure.

681,107, Aug. 20, 1901. A. H. Cowles, Cleveland, Ohio.

The arc type of furnace, with porous carbon walls, shown in prior patents 676,576, etc. In smelting a mixture of sodium aluminate and carbon, sodium and aluminium carbide result, the sodium vapor escaping through the walls and being condensed to a liquid in a chamber kept above 96° C. If iron, copper or tin be added to this mixture, the aluminium alloys therewith. If zinc be added, an alloy of sodium and zinc volatilizes. By mixing sodium and calcium compounds and proper amounts of carbon, sodium and calcium carbide may be produced.

682,088, Sept. 3, 1901. F. A. Kjellin, Gysinge, Sweden.

Induction resistance type, for smelting or heating ores and metals. The heating chamber is a horizontal annular body of refractory material, having a circular groove, with tapholes and a forehearth at one side. The inducing winding is a helix, within this body and inclosing one portion of the iron core, which is shown as a vertical (laminated) ring linked through the body.

683,089, Sept. 24, 1901. K. C. Wideen, New York City.

Arc type, for reducing metallic compounds, especially oxides, without the addition of carbon or other reducing agent. By means of mirrors, the heat of several arcs, or of the sun, is focused upon the compound, dissociating it. A charge of alumina is reduced by supporting it in a cavity in the top of a mound of alumina, or a block of asbestos, within a chamber having a roof of two transparent plates. The chamber is initially connected to a vacuum pump and the heating rays are concentrated downward upon the charge, raising it to about

10,000° Fahr. Aluminium of a purity of 99.23 per cent has thus been produced; also pure silicon, as stated. A reducing agent, e.g., a hydrocarbon gas, may be used.

683,107, Sept. 24, 1901. L. S. Dumoulin, Flushing, N. Y.

Resistance type, for smelting ore. The chamber has fire-brick walls, with openings at opposite sides receiving the resistor. This consists of a carbon bar with large ends, the thinner middle portion being covered with fireclay, applied plastic. The whole may be slipped into a loosely-fitting fire-clay tube for further protection. A furnace for smelting one ton of copper ore per day should have two horizontal resistors, placed 2 in. above the bottom, each consisting of a carbon bar 12 ft. long, their ends having a diameter of 2 in. and their intermediate portion of ¾ in. A current of 5000 watts is supplied.

684,296, Oct. 8, 1901. W. Nernst, Göttingen, and L. Glaser, Coburg, Germany.

Resistance type. The resistor is a "dry electrolyte," carrying preferably an alternating current. A mixture of magnesia and calcium carbonate, alumina, silica or kaœlin is preferred, magnesia alone having too high resistivity. The resistor is shown as a vertical tube, surrounded by a non-heat-conductor, e.g., loose magnesia, lime or alumina, inclosed in a jacket. This tube is preferably lined with pure magnesia, one or both sides of which lining may be covered with fine graphite to increase conductivity. Connection is preferably made to the ends of the resistor by bodies of compressed ferric oxide and metal clamps. The resistor is preferably preheated to the temperature to pass current by an internal carbon bar resistor, which is then withdrawn. The charge is then introduced, e.g., in a crucible pushed up from below. Preheating may be effected by a carbon or platinum resistor; or by an initial resistor-layer of powdered carbon or silicon, which burns away; or by burning coal-gas or a burning mixture of a solid combustible and a nitrate.

OBITUARY.

Mr. Gabriel L. Feldman, a leading expert in the electroplating industry, died on Sept. 16 at the age of 54 years, following an operation for appendicitis. Mr. Feldman was a native of Philadelphia, but became connected early in his life with the Hanson & Van Winkle Company, of Newark, N. J. During the 35 years of his connection with this firm he advanced through various positions to that of secretary of the company, which office he held at the time of his death. He leaves a widow, four daughters and three sons.

NEW BOOKS.

Becker, O. M. High-Speed Steel. The development, nature, treatment and use of high-speed steels, together with some suggestions as to the problems involved in their use. 360 pages, many illustrations. Price, $4 net. New York: McGraw-Hill Book Company.

Chwolson, O. D. Traite de Physique. Traduit par E. Davaux. Vol. III, part 2: General thermodynamics. Fusion. Vaporization. 340 pages, 206 illustrations. Price, in paper cover, 11 francs (retail price in New York, $3.65). Paris: A. Hermann & fils.

Fulton, Charles Herman. Principles of Metallurgy. An introduction to the metallurgy of the metals. 544 pages, 188 illustrations. Price, $5 net. New York: McGraw-Hill Book Company.

Klar, M. Technologie der Holzverkohlung. Second edition. 430 pages, 49 illustrations. Berlin: Julius Springer.

Treadwell, F. P. Analytical Chemistry. Vol. II. Quantitative Analysis. Translated by Wm. T. Hall. Second edition. 787 pages, illustrated. Price, $4. New York: John Wiley & Sons.

Van Nostrand's Chemical Annual, 1909. A handbook of useful data. Second edition. Edited by John C. Olsen. 580 pages. Price, $2.50 net. New York: D. Van Nostrand Company.

Bulletin No. 15, Illinois State Geological Survey. Geography of the Middle Illinois Valley by Harlan H. Barrows. 128 pages. Urbana: University of Illinois.

Iron Ore Resources of the Work. Summary composition upon the initiative of the executive committee of the Eleventh International Geological Congress, Stockholm, 1910, with the assistance of geological surveys and mining geologists of different countries. Edited by the general secretary of the congress. Accompanied by an atlas of 42 maps. Price $20. New York: Lemcke & Buechner.

Summary Report of the Mines Branch for 1909. 181 pages. Ottawa: Department of Mines.

BOOK REVIEWS.

A Text Book of Organic Chemistry. By William A. Noyes, professor of chemistry in the University of Illinois. 537 pages. Price, $1.50 net. New York: Henry Holt & Company.

Professor Noyes' text-book of organic chemistry appeared first in 1903. In the meantime a German translation was issued and in its introduction no less an authority than Wilhelm Ostwald expressed high praise on the great independence and originality shown by Professor Noyes.

The changes and additions which had been prepared for the German edition of the book have been included in the second American edition. The chapter on compounds of interest in physiology and pathology has been rewritten on the basis of the classification of proteins recently adopted by the American Society of Biological Chemists and the American Physiological Society.

The Construction of Graphical Charts. By John B. Peddle, professor of machine design, Rose Polytechnic Institute. 109 pages, 58 illustrations. Price, $1.50 net. New York: McGraw-Hill Book Company.

"Much of the work of calculation done by the engineer or designer is in the repeated application of a limited number of formulas to a variety of different conditions, which involves merely the substitution of different variables in identical equations.

"Any mechanical means for performing this operation expeditiously will not only lead to a saving of time and mental wear and tear, but will also minimize the chances for error.

"Such a device is the calculating chart, or nomogram, and the increasing frequency with which it is employed in the more recent technical publications is a good evidence of the growing recognition of its value.

"Many excellent examples of these charts have appeared of late years and are available for use, but it is evident that to realize their full value as useful instruments the engineer should have a sufficient acquaintance with their underlying principles to construct charts suited to his individual needs.

"Some of the chart forms employed to-day have been known and used for many years, but it is only within recent times that any systematic study has been made of the subject as a whole or any attempt to properly classify and correlate the different types.

"In this work the French have been pioneers, and it is to one of them, Maurice d'Ocagne, that we owe what is probably the most thorough and comprehensive text on the subject, his Traite de Nomographie."

Professor Peddle has done useful work in preparing for the use of the American engineer a simple and brief volume on the theory and practice of the construction of graphical charts. We believe it is the first of its kind in the English language. All mathematical explanations are made as simple as possible and numerical examples are added.

There are seven chapters dealing with the following subjects respectively: Charts plotted on rectangular co-ordinates; the alinement chart; alinement charts for more than three variables; the hexagonal index chart; proportional charts; empirical equations; stereographic charts and solid models.